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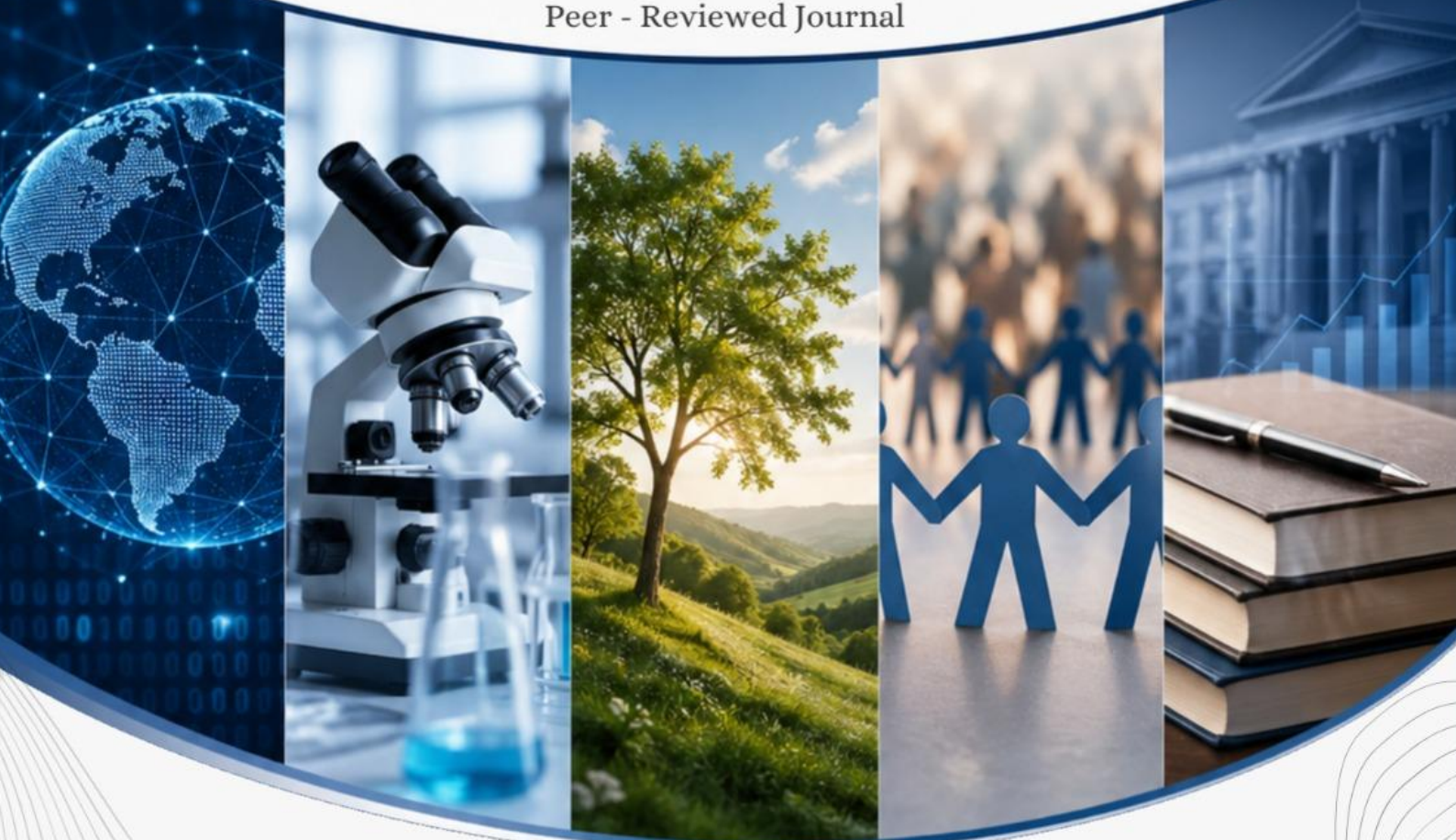
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The journal strives to foster intellectual collaboration, support evidence-based research, and promote ethical publishing practices while addressing emerging academic, technological, and societal issues. Through its commitment to quality and inclusivity, the GKU Journal seeks to make a meaningful contribution to the global research and academic community.

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As an open and inclusive platform for knowledge dissemination, the GKU Journal seeks to promote scholarly exchange among researchers, academicians, industry professionals, policymakers, and practitioners. It aims to strengthen collaboration between academia and industry while contributing to the advancement of national and international research communities.

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A Comparative Study of Nutritional Practices, Nutritional Awareness, and Barriers Among Male and Female Boxers of Kullu District, Himachal Pradesh

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Abstract— Nutrition is central to athletic performance, recovery, health, and safe weight management in combat sports. This comparative cross-sectional study examined nutritional awareness and nutritional practices among 60 under-19 district-level boxers from Kullu District, Himachal Pradesh, comprising 30 female and 30 male athletes selected through purposive sampling. Data were collected using structured questionnaires and analysed through descriptive statistics, Levene's test, independent-samples *t*-tests, Welch's correction where required, and Cohen's *d*. Female boxers recorded a higher nutritional awareness score ($M = 2.50$, $SD = 0.97$) than male boxers ($M = 2.17$, $SD = 0.70$), but the difference was not statistically significant, Welch's $t(52.6) = 1.52$, $p = .134$, $d = 0.393$. Female boxers demonstrated substantially better nutritional practices ($M = 26.50$, $SD = 4.36$) than male boxers ($M = 17.03$, $SD = 5.09$), $t(58) = 7.74$, $p < .001$, $d = 1.998$. The findings indicate that similar levels of awareness do not necessarily produce similar dietary behaviour. Practical nutrition education, accessible counselling, and

context-sensitive support are therefore recommended, particularly for young male boxers.

Keywords—boxing, combat sports, dietary behaviour, nutritional awareness, nutritional barriers, nutritional practices, sports nutrition.

I. INTRODUCTION

Req Boxing is a high-intensity combat sport that requires repeated explosive actions, sustained concentration, technical precision, and rapid recovery between training sessions and bouts. Appropriate nutrition supports energy availability, glycogen restoration, tissue repair, immune function, and body-composition management, making it an integral component of athletic preparation rather than an optional supplement to training [1]– [3].

The nutritional demands of boxing are complicated by weight-category requirements. Athletes may restrict food and fluid intake or employ rapid weight-loss practices to qualify for a lower category, even though severe energy restriction and dehydration can impair physiological function, cognition, mood, and performance. Evidence from combat-sport research therefore supports planned, gradual, and professionally supervised weight management [4], [5].

Carbohydrate availability is important for repeated high-intensity work, while adequate protein supports muscle repair and adaptation. Hydration is equally relevant because even modest fluid deficits can affect

endurance, reaction time, perceived exertion, and decision-making—capacities that are directly relevant to offensive and defensive actions in boxing [2]– [4].

Knowledge, however, does not automatically translate into behaviour. Reviews of athlete populations show that nutrition knowledge is frequently incomplete and that the association between knowledge and dietary quality is positive but modest. Food access, cost, convenience, training schedules, cultural preferences, family support, coaching advice, and online information may all shape what athletes actually eat [6]– [8].

Sex and gender may also influence dietary behaviour, access to guidance, body-image pressures, and the application of nutrition knowledge. Contemporary sports-nutrition literature emphasises that male and female athletes should be studied directly rather than assuming that one group represents the other, particularly during adolescence and early adulthood [11], [13].

II. RELATED LITERATURE & RESEARCH GAP

Heaney et al. concluded that athletes generally possess less nutrition knowledge than trained nutrition professionals and that differences in measurement instruments make comparisons across studies difficult. This observation is important because invalidated or poorly described questionnaires can obscure the distinction between general nutrition knowledge and sport-specific nutrition knowledge [6], [17].

Spronk et al. reported that female athletes scored higher than male athletes in both general nutrition knowledge and dietary quality, while the direct association between knowledge and diet quality remained weak. Their findings support the possibility that gender-related differences in eating behaviour

may be visible even when knowledge differences are small [7].

Vázquez-Espino et al. found that athletes obtain nutrition information from multiple sources and that attitudes, access to professional advice, and information quality influence dietary habits. Social-media exposure can expand access to information but may also increase exposure to unverified dietary claims and restrictive practices [8], [12].

Systematic reviews of nutrition education suggest that education programmes can improve knowledge and eating habits, although intervention effects differ according to programme duration, delivery mode, athlete characteristics, and the availability of individualised support. Education is most useful when it is combined with practical skills, food-environment changes, and follow-up reinforcement [9], [10].

Although sports nutrition and combat-sport weight management have been widely discussed, evidence concerning young district-level boxers from hilly regions of India remains limited. The food environment, travel distance, seasonal availability, household practices, and access to qualified sports dietitians may differ from those experienced by athletes in metropolitan or elite training centres. The present study addresses this contextual gap by comparing male and female boxers from Kullu District [5], [8].

III. AIM & OBJECTIVES

The study aimed to compare nutritional awareness, nutritional practices, and barriers to appropriate nutrition among male and female under-19 district-level boxers of Kullu District, Himachal Pradesh. The objectives were formulated to distinguish knowledge from behaviour and to identify areas requiring practical nutrition support [6]– [10].

- To assess and compare the daily nutritional practices of male and female district-level boxers.
- To assess and compare nutritional awareness among male and female district-level boxers.
- To identify the principal barriers that may hinder appropriate nutrition among young boxers.
- To examine whether observed gender differences are statistically and practically meaningful.

IV. METHODOLOGY

A. Research Design and Setting: A comparative cross-sectional descriptive design was used to examine nutritional awareness and practices in two naturally occurring groups at a single point in time. The reporting structure was aligned with relevant STROBE principles for cross-sectional studies, particularly a clear description of participants, variables, statistical methods, results, and study limitations [14].

B. Participants: The study included 60 under-19 district-level boxers from Kullu District, Himachal Pradesh, during the 2025–2026 session. Purposive sampling was used to select 30 female and 30 male boxers who were actively engaged in regular boxing training and competition. Eligibility required district-level representation, active participation in training, willingness to participate, and the absence of conditions that prevented questionnaire completion [14].

C. Instrument and Measures: Data were collected through a structured questionnaire covering nutritional awareness, routine nutritional practices, hydration, meal regularity, food selection, recovery-related eating, and perceived barriers to maintaining appropriate nutrition. Composite awareness and practice scores were used in the source dataset. Because the supplied manuscript did not report the item count, scoring range, or psychometric coefficients, the findings should be interpreted as

study-specific estimates rather than as population norms [6], [17].

D. Data-Collection Procedure and Ethical Considerations: Permission was obtained from the relevant coaches, sports authorities, and institutions before data collection. Participants were informed of the purpose of the study and completed the questionnaire under standardized conditions with adequate time and clear instructions. Participation was voluntary, confidentiality was maintained, and assent or consent procedures were followed as applicable; the source manuscript did not specify an ethics-approval reference number [14].

E. Statistical Analysis: Descriptive statistics included the sample size, mean, median, standard deviation, and standard error. Levene's test assessed homogeneity of variance. Independent-samples t-tests compared female and male groups; Welch's t-test was used when the equal-variance assumption was violated. Statistical significance was set at $\alpha = .05$, and Cohen's d was reported to indicate practical magnitude in addition to p-values [15].

V. RESULTS

A. Descriptive Statistics:

Table 1: Descriptive Statistics for Nutritional Awareness and Nutritional Practices

Variable	Group	N	Mean	Median	SD	SE
Nutritional awareness	Female	30	2.50	2.50	0.974	0.178
Nutritional awareness	Male	30	2.17	2.00	0.699	0.128
Nutritional practices	Female	30	26.50	26.00	4.361	0.796
Nutritional practices	Male	30	17.03	17.00	5.089	0.929

Table I shows that female boxers had a slightly higher nutritional awareness mean than male boxers, whereas the difference in nutritional practice scores was much larger. Standard deviations indicated

moderate within-group variation, and the practice scores were more dispersed among male boxers. Descriptive differences should be considered together with inferential tests and effect sizes rather than interpreted independently [15].

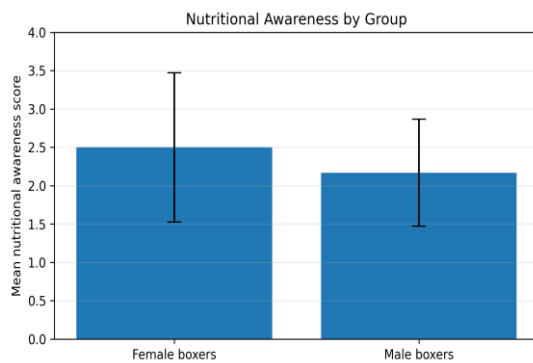


Fig. 1. Mean nutritional awareness scores with standard-deviation error bars.

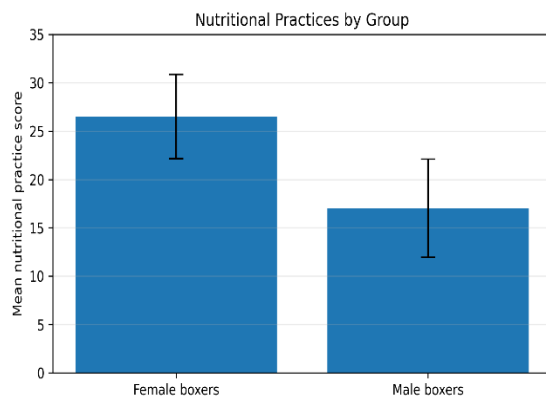


Fig. 2. Mean nutritional practice scores with standard-deviation error bars.

B. Homogeneity of Variance:

Table II
Levene's Test for Equality of Variances

Variable	F	df1	df2	p	Decision
Nutritional awareness	5.800	1	58	.019	Equal variances not assumed
Nutritional practices	0.471	1	58	.495	Equal variances assumed

Levene's test was significant for nutritional awareness ($p = .019$), indicating that the equal-variance assumption was not satisfied; therefore, Welch's result was used for the principal

interpretation. The test was not significant for nutritional practices ($p = .495$), so the conventional equal-variance t -test was appropriate for that comparison [15].

C. Independent-Samples Comparisons:

TABLE III
INDEPENDENT-SAMPLES t -TEST RESULTS

Variable	Test	t	df	p	Cohen's d	Interpretation
Nutritional awareness	Student's t	1.52	58.0	.133	0.393	Not significant
Nutritional awareness	Welch's t	1.52	52.6	.134	0.393	Not significant
Nutritional practices	Student's t	7.74	58.0	< .001	1.998	Significant
Nutritional practices	Welch's t	7.74	56.7	< .001	1.998	Significant

The awareness comparison was not statistically significant, Welch's t (52.6) = 1.52, $p = .134$. Although the female mean was higher, the observed standardized difference was small-to-moderate ($d = 0.393$) and did not provide sufficient evidence of a gender difference at the .05 level [15].

Nutritional practices differed significantly between groups, t (58) = 7.74, $p < .001$. Female boxers scored 9.47 points higher on average than male boxers, and the reported effect size was very large ($d = 1.998$). The result indicates both statistical significance and substantial practical separation between the group means [15].

D. Barrier-Related Observations: The questionnaire was described as including barriers to appropriate nutrition, such as availability, affordability, training schedules, travel, limited access to qualified guidance, and dependence on informal information sources. However, item-level barrier frequencies and gender-specific barrier scores were not included in the supplied results; consequently, no additional numerical comparison was created. Similar structural

and information-related barriers are recognized in athlete nutrition research [8], [12].

E. Summary of Statistical Decisions:

TABLE IV
SUMMARY OF GROUP-COMPARISON
FINDINGS

Outcome	Female Mean	Male Mean	Principal Test	Decision
Nutritional awareness	2.50	2.17	Welch's $t(52.6) = 1.52, p = .134$	No significant difference
Nutritional practices	26.50	17.03	$t(58) = 7.74, p < .001$	Significant difference
Nutritional barriers	Not reported	Not reported	Item-level data unavailable	Descriptive only

The combined pattern shows a knowledge behavior discrepancy: awareness levels were broadly comparable, while actual nutritional practices differed markedly. Because no individual-level correlation analysis was reported, the findings should not be interpreted as proving that awareness caused or failed to cause particular behaviors [7], [15].

VI. DISCUSSIONS

The non-significant difference in nutritional awareness suggests that male and female boxers were exposed to broadly similar levels of nutrition-related information. Shared coaches, training settings, peer networks, and media sources may have contributed to this convergence. Athlete knowledge studies similarly show that exposure to information is common but the depth and accuracy of knowledge vary considerably [6], [8].

The substantially higher nutritional practice scores among female boxers are consistent with evidence that female athletes may report better diet quality or healthier food-selection patterns than male athletes. Spronk et al. observed higher nutrition knowledge and diet-quality scores among female athletes,

although the association between knowledge and dietary quality was weak [7].

The present findings therefore support a distinction between knowing and doing. Nutritional behavior depends on motivation, convenience, food availability, family practices, finances, scheduling, and the credibility of advice. Education that merely supplies facts may be less effective than programme that include meal planning, label reading, hydration routines, recovery-food options, and strategies for travel and competition days [8]– [10].

For young boxers, this behavioral distinction is especially important because weight-category pressures can encourage restrictive eating and dehydration. Coaches and athletes require clear guidance that separates evidence-based weight management from unsafe rapid-loss practices. Regular monitoring, early referral, and realistic body-mass targets can reduce the pressure to use harmful methods close to competition [4], [5].

The female group's stronger practice scores should not be interpreted as evidence that female athletes have no nutrition-related vulnerabilities. Female athletes may face distinct concerns involving energy availability, iron status, menstrual health, body image, and social pressures; sex- and gender-responsive guidance remains necessary even when routine practices appear favorable [11], [13].

The very large practice-score effect is noteworthy but should be interpreted within the study context. The sample was purposively selected from one district, the questionnaire properties were not fully described, and cross-sectional comparisons cannot determine whether gender itself produced the observed difference. Replication with validated measures and multi-site sampling is required [14], [15].

VII. PRACTICAL IMPLICATIONS

Nutrition education for district-level boxers should combine short classroom sessions with practical

activities such as preparing affordable recovery meals, planning hydration, identifying reliable information sources, and creating competition-day food schedules. Systematic reviews indicate that structured education can improve knowledge and dietary behavior, particularly when repeated and tailored to the sporting context [9], [10].

Male boxers may benefit from targeted behavioral support because their awareness scores were not significantly lower, yet their practice scores were substantially poorer. Coaches should avoid assuming that information alone will change behavior and should instead monitor meal regularity, fluid intake, post-training recovery, and risky weight-control strategies [5], [8].

Local programs should account for the food environment of Kullu District by using accessible, culturally familiar, and affordable foods. Referral pathways to qualified sports-nutrition professionals, periodic parent or guardian engagement, and coach education could reduce dependence on peers and social media as primary sources of dietary advice [8], [12].

VIII. LIMITATIONS & FUTURE RESEARCH

The study has some limitations, including a small purposive sample from one district limiting generalizability. The group difference in a cross-sectional design does not allow temporal sequence or causation. The potential for recall and social-desirability bias also affects self-reported answers [14].

They were not reported in the source manuscript, which either provided no item count for the questionnaire, scored from samples of 20 items out of a maximum 25 (a score range would be helpful), presented preliminary reliability or validity evidence, and our intent was to quantify responses at an item-level by barrier. This means that absolute scores

cannot be fully interpreted and also limits cross-comparison of nutritional barriers. Future studies must utilize validated sport-nutrition instruments and report psychometric properties clearly [6], [17].

Suggestions for future research also include studying larger samples drawn from multiple districts, analyses by age group, weight-category information (weight-class or sport-type), training volumes, dietary recalls (e.g. 1-d food diaries) that inform more direct estimates of energy intake and expenditure in the same day, hydration measures (e.g. urine-specific gravity), and body-composition indicators such as skinfold thicknesses. Pragmatic studies with longitudinal or intervention designs would ultimately show whether education in practical terms enhances behavior and whether these changes contribute to improved recovery, safe weight management and boxing performance [9], [10].

IX. CONCLUSION

The study found no statistically significant gender difference in nutritional awareness among under-19 district-level boxers from Kullu District. In contrast, female boxers reported significantly better nutritional practices than male boxers, with a very large effect size. The findings demonstrate that broadly similar awareness can coexist with markedly different dietary behavior [7], [15].

Nutrition support for young boxers should therefore move beyond awareness campaigns and address practical barriers, routines, access to credible guidance, and safe weight-management behavior. Context-sensitive counselling and coach-supported monitoring may help athletes translate knowledge into consistent practice while protecting health and performance [5], [8]–[10].

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Comparative Analysis of Mental Toughness Among Medallist and Non-Medallist University Archery Players

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Abstract— The well-documented relationship between sport performance and psychological factors shall, however, now be emphasized: While physical ability and technical skill associate high-performance athletes with each other, the question of how they deliver under pressure is defined by their psychological make-up. The current study evaluated and compared mental toughness between medal winning ($n=54$) university archery players with non-medallists ($n=32$) on four domains of Commitment/Motivation, Concentration/Focus, Control Under Pressure and Confidence/Self-Belief measured by The Mental Toughness Scale. Purposive sampling was conducted for selecting a total of forty archers (20 medallists and 20 non medals) in the age category of 18-25 years. A modified version of the Alan Heary Mental Toughness Test served to assess mental toughness through a 24-item questionnaire. Independent-samples t -tests revealed significant differences between groups for all four components of well-being and the global composite score ($p < 0.001$). As per the scoring system employed, Medallists earned a lower overall mean score ($M = 4.45$, $SD = 1.61$) than non-medallists ($M = 14.20$, $SD = 2.42$), which provides greater evidence for mental toughness compared to their mates who did not achieve medals. These findings provide the first evidence that commitment, attentional control,

pressure management and self-belief are potential resilience factors directly linked to competitive performance in university-level archery.

Keywords —archery, medallist, mental toughness, precision sport, sport psychology, university athletes.

I. INTRODUCTION

It is the interaction of physical characteristics, technical skills and tactical judgment with psychological readiness that determines sport performance. Athletes are often required to maintain emotional stability, sustained concentration, and self-assurance in the face of evaluative demands. This conceptualization of mental toughness has led to pervasive discussions about it being a multifaceted psychological trait that is linked to psychological consistency, persistence, control, and efficient coping in the context of demanding sport environments. [1]- [4].

Some small disturbances in attention, arousal, breathing, posture or confidence can affect shot execution; thus archery is a precision sport. Investigations in top-level and expert archers have been associated performance with attention, psychophysiological regulation, emotional control, and self-confidence. As a result, psychological preparation is not an additional layer on top of technical training; it constitutes a necessary

component of sustaining a reliable shot routine over long tournament rounds. [5]- [8].

At the university level, athletes often compete against opponents with broadly comparable technical preparation. Under these conditions, the ability to remain focused after an error, manage competitive stress, sustain motivation, and preserve self-belief may help distinguish medal-winning performances from non-medal-winning performances. Examining these dimensions among university archers can therefore provide practically relevant evidence for coaches and physical-education specialists. [3], [7]- [9].

II. OBJECTIVE & HYPOTHESIS

The objective of the study was to compare medalist and non-medalist All India Inter-University archery players on overall mental toughness and on four sub-components: Commitment/ Motivation, Concentration/Focus, Control Under Pressure, and Confidence/Self-Belief. The null hypothesis stated that no statistically significant group differences would occur, whereas the alternative hypothesis stated that medalists and non-medalists would differ significantly on the measured dimensions. [1], [4].

III. METHODOLOGY

A. Selection of Subjects: The study included forty (N = 40) All India Inter-University archery players aged 18-25 years. The sample comprised twenty medallists and twenty non-medallists selected through purposive sampling because participation status and competitive achievement were essential eligibility criteria. Medallists were players who had secured a gold, silver, or bronze medal at the All India Inter-University level; non-medallists had participated at the same competitive level without winning a medal. [19].

B. Selection of Variables: The performance status was considered the explanatory variable and divided into medallist or non-medallist. The dependent

variable was mental toughness as summarized by the composite score of Commitment/Motivation, Concentration/Focus, Control Under Pressure and Confidence/Self-Belief. This multi-dimensional treatment is consistent with established sport-psychology approaches that regard mental toughness as coalesced capacities of related but non-isolated psychological characteristics not merely a singular military trait. [2], [4].

TABLE I
VARIABLES OF THE STUDY

Type of Variable	Variable	Description
Independent Variable	Performance Status	Medalist / Non-Medalist
Dependent Variable	Mental Toughness	Composite score from four sub-components

C. Criterion Measure and Scoring: Mental toughness was assessed using an adapted questionnaire of the Alan Heary Mental Toughness Test. The instrument included a total of 24 items, with six in each of the four sections: Commitment/Motivation, Concentration/Focus, Control Under Pressure, and Confidence/Self-Belief. One point for each checked and zero points for each unchecked statement, yielding a possible total score ranging from 0 to 24. Scores in the range 0–4 are labelled as Thriving, scores 5–14 as Surviving, and scores 15-24 as Struggling, under the interpretation adopted (with lower scores indicating greater mental toughness). [12].

D. Statistical Techniques: We computed the means and standard deviations for both groups. Independent-samples t-tests were conducted to compare medallist's and non-medallist's on the four components, as well as the overall score. Statistical significance was judged at the 0.05 level, with 38 degrees of freedom for the reported group comparisons. Due to the fact that the design was cross-sectional, and group membership was not

experimentally manipulated: While the analysis identifies group differences, it does not demonstrate causation. [20].

IV. RESULTS

The descriptive statistics are presented in Table II. Because the adopted instrument is negatively scored, a lower mean indicates a stronger mental-toughness profile. Across every component, medalist's recorded lower scores than non-medalist's, indicating fewer reported weaknesses in commitment, concentration, control under pressure, and confidence. [12].

TABLE II
DESCRIPTIVE STATISTICS FOR MENTAL TOUGHNESS SCORES (N = 40)

Component	Medallists Mean (SD)	Non-Medallists Mean (SD)	Category (Med.)	Category (Non-Med.)
Commitment / Motivation	1.20 (0.83)	3.75 (1.25)	Low weakness	Moderate weakness
Concentration / Focus	1.05 (0.83)	3.85 (1.14)	Low weakness	Moderate weakness
Control Under Pressure	1.05 (0.60)	3.15 (1.31)	Low weakness	Moderate weakness
Confidence / Self-Belief	1.15 (0.93)	3.45 (1.05)	Low weakness	Moderate weakness
Overall Mental Toughness	4.45 (1.61)	14.20 (2.42)	Thriving (0-4)*	Surviving (5-14)

Note: Lower Mean Scores Indicate Higher Mental Toughness.

**The Medalist Group Mean of 4.45 Is Close to, But Slightly Above, The Individual-Score Thriving Cut-Off of 4; Therefore, The Category Label Should Be Interpreted Descriptively at The Group Level.*

The medalist group obtained an overall mean of 4.45 (SD = 1.61), whereas the non-medalist group obtained a mean of 14.20 (SD = 2.42). The medalist mean was close to the upper boundary of the Thriving band, while the non-medalist mean was at the upper boundary of the Surviving band. The same direction of difference was observed across all four sub-components, showing a consistent descriptive advantage for medalists under the questionnaire scoring framework. [12]

Table III presents the inferential comparisons. Every obtained t-value exceeded the critical value of 2.024 at $df = 38$, and each reported probability was below 0.001. The null hypothesis was therefore rejected for all four sub-components and for the overall mental-toughness score. [20].

TABLE III
INDEPENDENT-SAMPLES T-TEST
COMPARISON OF MEDALISTS AND NON-MEDALISTS

Component	Medallists Mean	Non-Med. Mean	t-value	p-value	Result
Commitment / Motivation	1.20	3.75	7.585	< 0.001	Significant
Concentration / Focus	1.05	3.85	8.913	< 0.001	Significant
Control Under Pressure	1.05	3.15	6.513	< 0.001	Significant
Confidence / Self-Belief	1.15	3.45	7.322	< 0.001	Significant
Overall Mental Toughness	4.45	14.20	15.019	< 0.001	Significant

Significant at The 0.05 Level; Critical T = 2.024, Df = 38.

Commitment/Motivation differed significantly between medalists and non-medalists ($t = 7.585$, $p < 0.001$). Concentration/Focus produced the largest sub-component t-value ($t = 8.913$, $p < 0.001$), followed by Confidence/Self-Belief ($t = 7.322$, $p < 0.001$) and Control Under Pressure ($t = 6.513$, $p < 0.001$). The overall comparison was also significant ($t = 15.019$, $p < 0.001$), indicating a substantial

separation between the two groups on the composite score. [20]

V. DISCUSSIONS

From the analysis, medalist university archers reported a more positive mental-toughness profile than non-medalists. The outcome aligns with conceptual accounts in which mental toughness facilitates appraisal, coping, persistence, and performance under pressure or adversity for athletes. However, medal status and mental toughness were assessed concurrently, thus the finding should be regarded as an association rather than evidence of causation of competitive success by mental toughness. [1], [3], [4].

An important discrepancy in Commitment/Motivation indicates that medalists may be more steady about keeping at training goals and maintaining effort during adversity. Commitment diligence and perseverance with longer term goals are traits that show up in research on mentally tough performers. Those traits can allow players to maintain training standards post-poor performances and still pursue performance goals at the season level [1], [14], [17].

The area where this first really showed variance between the two groups was, not surprisingly given my previous writing, Concentration/Focus (the greatest difference of the four sub-components). This outcome is particularly important in archery, which demands that athletes focus attention on task-related information while ignoring opponent, rank, previous shots and expected outcomes. Similar results have also been shown through research conducted on archers, where attention and confidence play a role in determining performance (Gonzalez et al., 2014), with psychological-skills training being found to positively impact processes

relevant to both enhancements of these mental abilities. [5], [7], [8], [10].

The discrepancy in Control Under Pressure is consistent with the notion that high level of athletes is greater at self-regulating arousal and functional interpretation of competition sensations. For precision sport, high amounts of cognitive interference or unregulated anxiety might disrupt fine motor control and shot consistency. Consequently, medalists may have more consistent pre-shot routines and better control over emotional and physiological responding when it mattered most. [6], [11], [13].

The large difference in Confidence/Self-Belief is predicted by self-efficacy theory which states that perceived capability affects effort and persistence and responses to difficulty. A stable sense of competence may protect an archer from a sub-par shot and help them re-adjust their shot in light of better odds in overcoming a poor execution error on the next attempt. Similarly, more recent research on sport-confidence illuminates these constructs in archery contexts as substantial determinants of attention and subsequent competitive performance [8], [9].

VI. LIMITATIONS & PRACTICAL IMPLICATIONS

Several limitations should be considered in light of these findings. The results cannot be generalized to different age groups, competition levels or archery disciplines, as the sample was small and selected purposely from only All India Inter-University players. Moreover, this study used self-report data and the reliability or validity coefficients of the modified questionnaire were not provided for the current sample. Future work using larger samples, should report psychometric evidence and combine psychological characteristic in competitive archery. [5], [7], [8]. It is common for coaches to add

structured psychological preparation in addition to technical and physical elements as part of a training routine. That likely includes goal-setting, attentional-control exercises, imagery, breathing regulation, confidence-building routines and practice that simulates competition pressure. In our experience, because archers appear to react differently to specific emotion-regulation tactics, it is best that these strategies are individually tailored and continually monitored rather than implemented as a blanket programme [7], [8], [10].

VII. CONCLUSION

- Medalist All India Inter-University archery players recorded a lower overall mental-toughness score ($M = 4.45$, $SD = 1.61$) than non-medalists, indicating a stronger psychological profile under the scoring system used. [1], [4].
- Non-medalist players obtained an overall mean score of 14.20 ($SD = 2.42$), indicating greater reported weakness in commitment, concentration, pressure control, and self-belief than the medalist group. [3], [4].
- Statistically significant group differences were reported for Commitment/Motivation ($t = 7.585$), Concentration/Focus ($t = 8.913$), Control Under Pressure ($t = 6.513$), Confidence/Self-Belief ($t = 7.322$), and overall mental toughness ($t = 15.019$), with $p < 0.001$ in every comparison. [20].
- Concentration/Focus produced the largest sub-component difference, highlighting sustained task-relevant attention as a particularly important psychological characteristic in competitive archery. [5], [7], [8].

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Education and Equity in the 21st Century: Advancing SDG-4 Through Technology and Inclusive Growth

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Abstract— This article examined the effect of a well-structured six-week weight-training program on basketball throwing performance among intercollegiate players. Twenty male basketball players of the District Stadium of Nagaur, Rajasthan, between 18 and 25 years, were randomly selected. These players are assigned to the experimental group ($n = 10$) and the control group ($n = 10$). The experimental group received training as suggested, while the control group continued with its regular activities without training. Before and after the treatment, Basketball throwing ability was measured. The analysis of covariance (ANCOVA) was used to compare the groups, controlling for their pre-test performance at a 0.05 significance level. There was no significant difference in the pre-test ($F=0.45$), suggesting initial homogeneity. Across-test ($F = 7.73$). Two adjusted post-test scores differed between groups: $F(1,17) = 9.18, p = .008$. Of the two groups, the intervention group's adjusted mean was 176.10 while that of the control was 165.47. The sums of squares reported yield a partial eta squared of 0.351. Based on the research findings, a structured program has resulted in a significant enhancement in the basketball throwing ability of the players.

Keywords—basketball, intercollegiate players, muscular strength, throwing performance, weight training.

I. INTRODUCTION

Basketball is a team game that uses high intensity. The technical execution of basketball depends on coordinated contributions of fitness, tactics,

perception, and cooperation. To perform competitively, players have to repeatedly accelerate, decelerate, change direction, jump, and execute pass, shoot, rebound, and defend actions in a time-constrained environment. [1], [2].

Thus, muscular strength and power form the basis of basketball conditioning. Power comes from strong muscle mass and helps generate force quickly. Those who have power are explosive. Agility, speed, flexibility, endurance, and neuromuscular coordination work together to optimize movement in competition. [3]– [5].

The ability to throw accurately is especially relevant to long-range passing and the execution of the fast break, along with the movement of the ball on offense. When we throw an object, the lower limbs, trunk, shoulder girdle, arm, and wrist coordinate. Despite the necessity of technique, a sufficient level of strength may allow players to transmit force through the kinetic chain and maintain performance in passing on repeated efforts. [1], [5].

Structured resistance training has become popular for enhancing strength, power, and sport-specific performance. Research on athletes indicates that scientifically designed programs can enhance physical abilities, provided that load, exercise selection, recovery, and progression are managed. Studies on basketball conditioning indicate that combined and compound training may improve specific selected fundamental skills and performance qualities. [6]– [9]. Although strength, sprinting, jumping, and overall basketball fitness have received a great deal of study, much less has been done in controlled studies of basketball

throwing ability in intercollegiate players in regional training settings. The current study aimed to investigate the effect of a six-week structured weight training program on the throwing performance of male intercollegiate basketball players of Nagaur, Rajasthan. [1], [5], [6].

II. REVIEW OF RELATED LITERATURE

According to broader strength-training academic literature, muscular strength is a key quality that can affect power, speed, change-of-direction ability, and the ability to perform a sport-specific task. According to a meta-analysis of the literature, the effects of the training depend on the variables of the program. These include things like training status, intensity, volume, and progression. [4], [8], [9].

Supervised, properly designed resistance training improves the strength and functional performance of younger athletes, including children and adolescents.

There is a strong consensus in the literature on the use of progressive loading, qualified supervision and movement quality, rather than the indiscriminate application of heavy resistance. [7], [10].

According to Christou et al., resistance training along with sport practice improved strength and selected physical capacities in adolescent soccer players. While the sport is different from basketball, the results show that there are benefits to the inclusion of structured resistance exercise with technical training for developing young athletes. [7].

Other sports research has also shown transfer from strength-focused exercise to performance variables. Azeem and Ameer reported gains in strength along with positive alterations of sprint and flexibility, Elsayy reported benefits of functional strength training for physical and kicking variables in taekwondo, and Ibrahim found gains in arm strength

and defensive performance among players of sitting volleyball. [12]– [14].

The configuration of training carries enormous significance. The way sets are completed was shown to affect adaptation (Inquired et al.), while adaptations in strength, power, and functional performance following strength training were documented (Hanson et al.). Fatuous et al. also showed that resistance training can be planned without interference to flexibility if planned appropriately. [15]– [17].

Current research offers more direct support for basketball-related research. A six-week compound training program led to enhanced basketball fundamental skills, according to in overo and Pagaduan. According to the reviews and application analyses of Oliver et al., Locke and Jeffries and Turner and Stewart, strength and conditioning is an important aspect in the physical preparation of basketball players. [1], [2], [5], [6].

Resistance training must still be well-balanced and technique-controlled. Kolber et al. indicated that shoulder problems could occur when resistance exercises are poorly selected or executed. The worry is especially pertinent to throwing tasks which place repeated load on the shoulder complex. Hence, the evidence that was reviewed supports structured and supervised training, but the lack of direct evidence of intercollegiate basketball throwing performance justifies the present study [11].

III. PURPOSE, OBJECTIVES & HYPOTHESES

The idea of inclusive education is underpinned by many concepts. According to the theory of Sociocultural Learning, people learn cultural norms and values through interaction and the use of different cultural tools. Training should connect with what the learner already knows, but it should also provide relevant scaffolding. As per the

contemporary conversation around the science of reading, the scientific evidence must be connected to the specific learner's particulars rather than to generic, simple solutions. Strategies that are adaptable and evidence-based are inclusive.

UDL allows for flexible learning environments and proactive design. A course must consider barriers in its design. At times, failure makes students aware of obstacles. This quotation gives more details. Research into UDL and inclusive education indicates that various curricular designs, materials, and participation routes can engage a wider range of learners [7]. A distinct and reasonable adjustment is necessary and proper. However, UDL differs from these in its emphasis on the barriers created by inflexible systems, rather than 'deficits' present in the learner. Multiple voices often get ignored in classrooms. Who is making the voice?

Read More - Find Out More Bias can be explicit but may also arise through more commonplace interactions, low expectations, stereotyping, or micro aggressions. The learning environment framework offers recommendations for descriptively addressing micro aggressions. Moreover, it centres on health professional education contexts of learning environments. Studies of interventions with equality objectives as a central focus reveal that, as they move along the design-execution-review continuum, outcomes are more likely to make an impact, but only if equality is not a tag-on but is organically built into the process[9].

The perspectives should cooperate with each other, which further helps towards a conception of inclusion as the redesign of systems, relations, and opportunities [9].

IV. INTERNATIONAL POLICY & IMPLEMENTATION

As per the Convention on the Rights of Persons with Disabilities and SDG-4, inclusion in education is perceived as a right, not a choice. Commitment does not guarantee inclusive classrooms. A review of intervention studies conducted in low- and lower-middle-income countries found that implementation depends on teacher preparation, resourcing, leadership, local fit, and longer-term institutional support. This finding illustrates how similar wording policies can yield different results in diverse countries and regions.

Policies that are informed are equally important. The OECD observes that the three, research, policy choices, and practice, remain disconnected. To mitigate this gap, usable evidence, a professional dialogue, implementation support and monitoring mechanisms to check whether the policies enhance participation and learning are required. Finland's example of an integration-focused approach and the United States' example focusing on legal entitlement regarding disability are commonly cited. Utilization of the borrowing by other systems, nevertheless, demands careful assessment of local governance and funding, teacher workload, and cultural expectations. Enrolments numbers are not the only measure of success. Indicators of interest include attendance and participation in classes, access to materials, sense of social belonging, as well as completion, achievement, transition, and learner or family experience. A school that appears inclusive of people on the surface is not really inclusive. There are a variety of forms it could take It is important to connect legal entitlement to operational capacity at school and classroom in effective policy.

V. BARRIERS TO INCLUSIVE & EQUITABLE EDUCATION

Socioeconomic inequality remains one of the most resistant barriers. Low-income family learners might have limited access to health care, computers or stable internet connectivity due to lack of transport, assistive devices, private study space, books, tutoring and nutrition. This negative feedback may get worse because schools serving communities that are already marginalised get less money as well. Funding sensitive to inequalities should be based on need, rather than per capita basis.

When curricula and assessments are framed in one language and one experience, linguistic and cultural diversity creates further difficulties. Students may understand topics, but they cannot show that understanding due to unfamiliar language forms. Mismatch can be reduced through culturally responsive teaching, multilingual support, representative curriculum content. The importance of differentiated instruction is also the fact that it allows the teacher to vary content, process, support and forms of demonstration according to readiness and learning profile. Teachers' stories of differentiated instruction in inclusive classrooms emphasize its usefulness together with the need for stronger preparation and help in practice.

Inadequate teacher preparation and inflexible curricula, lavage classes and buildings that are not easily accessible, limited specialist services and fragmented administrative structures and weak accountability all represent institutional barriers to learning and participation in education. According to research on preservice teachers in Qatar, providing structured preparation can enhance attitudes towards inclusion, suggesting that beliefs are not fixed but rather can be modified through appropriate knowledge and guided experience [13]. Simultaneously, the standards of the institution must

be cleared through leadership and bias. Experiences of diversity-policy implementation in another profession teach us that declarations have to be changed into something measurable, a commitment to accountability and organisational change for reducing disparities [14].

Disaster increased barriers and highlighted the need for resilience and sustainability. Broad scholarship since the pandemic has stressed that recovery should not be business as usual but must address the vulnerabilities revealed by the crisis 15. In education, resilience is about creating learning pathways that are as flexible as possible, without transferring the cost of participation to those families who have the least ability to absorb such costs.

VI. EQUITY, EQUALITY & INCLUSIVE PRACTICE

The common distinction between providing all students with equal assistance and offering all students the assistance they need to participate equally clearly illustrates the useful distinction between equality and equity [2]. Equal amounts may be appropriate when needs are the same; equitable amounts are necessary when barriers differ. Providing the same digital device to all students will not ensure equal participation if some students do not have internet access, accessible software, a consistent electricity supply, language support, and a quiet place to work.

The term "equity" does not imply lessening academic standards but rather maintaining essential learning outcomes while removing obstacles that do not contribute to the accomplishment of those outcomes. Different assessment formats ensure that students demonstrate what they have learned and reduce barriers for any specific group of students. They include a multimedia assessment supplemented with captions, accessible resources

compatible with a screen reader, extra time to process the assessment task, alternative ways of responding, and relevant content support for language. By engaging collaboratively with reciprocal support, inclusive pedagogy steers clear of both rigid uniformity and needless segregation. Schools must examine their own policies that regulate discipline, ability grouping, referral patterns, and expectations. Systems perceived as neutral may yield quite different results. Data on disability, gender, language, location, and wealth status, with privacy safeguards and bias detection capabilities. A mainstreaming approach promotes the incorporation of equality considerations across policy domains, rather than being added afterward once decisions are being made [9].

VII. TECHNOLOGY & DIGITAL INCLUSION

Inclusive education and technology both call for making content more accessible, allowing greater flexibility in pace, supporting communication, facilitating formative feedback, and encouraging a wider participation. Medar et al. (2015) point out that the influence of technology on learning has been investigated in several studies which concluded that if properly supported, technologies such as a computer, a tablet, a smartphone, robotics, simulations etc. can greatly enhance learning opportunities and can promote equity.

Assistive technologies like TTS/STT, alternative keyboards, screen reader, and magnification, captioning, communication devices, etc., and learning-management systems designed for accessibility, help remove barriers for persons with disabilities to participate.

Digital literacy is a key component of this. Students with special educational needs may need direct teaching on how to use platforms, manage files, assess information, protect privacy and use

accessibility features. The literature available on digital literacy strategies for these learners finds pedagogy that offers success by creating social, technical and cognitive grounding rather than mere exposure [17].

Some immersive and Metaverse-based education video are relatively new digital learning environments that can simulate, visualize, collaborate, and learn by experience or participation. These amazing benefits do not come cheap. The framework of Metaverse in education: concept has research generated framework for the potential of metaverse in education and identifies challenges for implementation that requires further study What really matters is not whether technology is innovative, but whether it improves learning, access, agency and safety of the end-user.

People's experiences during COVID-19 are an important source of evidence. The involvement of parents and the main role of special teachers are based on the individual plan for the disabled student. In the aftermath of the pandemic, the higher education sector seems to have made similar claims about striking a balance between technology and pedagogic and human elements, rather than examining how online delivery can be seen as a substitute for educational design [20]. Primary teachers in Indonesia [21] also reported practical issues in relation to equity of access or engagement. According to evidence relating to maths teachers, digital provision of any sort should, at least in part, be planned around prevailing access conditions.

An affordable connectivity strategy, device access, accessible procurement standards and adequate local development funds to cover low bandwidth options along with offline content and technical support should be part of the strategy to achieve digital safety education and training of teacher's students and their families. It is essential to check the

algorithms and learning analytics for being biased with other agendas. It is important to see these conditions as a core education infrastructure rather than ancillary ones for technology to become an equity tool.

VIII. TEACHER PREPARATION & PROFESSIONAL DEVELOPMENT

Inclusive education cannot be implemented without teachers, as policy is made significant through classroom decisions. Preparation should include some consideration of learner variability, differentiation, UDL, formative assessment, behavior support, multilingual pedagogy, collaboration with specialists, assistive technology, and family communication. Teachers must secure practical experience to have opportunities to plan, teach, observe, receive feedback, and reflect in diverse environments.

The efforts and persistence of inclusive strategies are strongly influenced by teachers' beliefs and self-efficacy. Teachers' self-efficacy and inclusion beliefs are interrelated [22]. A meta-analytic study also says that teachers' beliefs are influenced by training, experience, perceived competence, and contextual support [23]. Research in Chile shows similar results: attitudes, intentions, and self-efficacy are associated with varying levels of inclusion [24]. The findings indicate that professional development should enhance knowledge and confidence while improving the organizational conditions in which teachers work.

One-off workshops are seldom enough. You will have the chance to keep learning, engage in professional development, and receive coaching. Also, there will be time for reviewing and sharing professional practice and collaborative planning time with colleagues who have similar interests through participation in communities of professionals. You may have case discussions which

may involve a large workload and running for a period of time, as well as getting access to the advice and expertise of specialists. Attitudes may vary according to preservice preparation [13]; classroom-oriented work on differentiated instruction is, after all, more representative of the nexus of theory and realities and constraints [12]. A balanced approach to developing them is highly recommended. Everyone learns at their own pace, and everyone deserves to go through some pretty impressive trouble to study what they want to.

IX. PARENTAL & COMMUNITY ENGAGEMENT

Families have important insights into what helps learners thrive in relation to their likes, support needs, strengths as communicators, and routine! The level of engagement must go beyond informing parents of decisions and must involve listening, shared planning, and communicating in a user-friendly way that respects linguistic and cultural preferences to be meaningful. Community organizations can provide mentors, transport and digital access, health and social support, and learning opportunities beyond school. The benefits of strong parental and community involvement are well-researched and lead to improvements in educational support and other social outcomes [25]. Although the epidemic highlighted the relevance of these partnerships, it also revealed varying family capabilities within this system. Some families had the privilege of providing expertise over online learning and multiple devices; meanwhile, other families were contending with job loss, digital illiteracy, overcrowding, or language obstacles. Low participation should not be a sign of apathy, according to schools. Tools that can help level the playing field include access, geographic-specific translation support, scalable community-based

language resources, and non-digital ways for people to participate.

X. POLICY RECOMMENDATIONS

To begin with, financing formulas must be sensitive to equity. The extra capacity should be aligned with educational needs and enhance accessibility infrastructure, assistive technology, specialist staff, connectivity, teaching and learning resources, and teacher capacity development. The recorded barriers regarding SDG-4 demonstrate that policy pronouncements alone cannot yield quality education without material capacity [3].

Moreover, curriculum design, assessment, buildings, transport, digital procurement, and institutional procedures must be fully accessible and not discriminate against anyone. Policies must address horizontal discrimination and indirect exclusion caused by inflexible rules. A system should be created for complaints, remedy, monitoring, and public reporting so that rights can be enforced rather than stated.

Governments and institutions are responsible for strengthening the research-implementation link. Evidence ought to be converted to practical guidance, piloted in context, and assessed through participation and learning outcomes. The OECD [11] indicates that the research-policy divide can be narrowed through partnerships between researchers, teachers, school leaders, communities, and policymakers.

Furthermore, Digital inclusion must be treated as a public education function. Include connectivity, devices, affordable data, support, and skills in your planning process. Policymakers must incorporate low-bandwidth and offline alternatives in emergency and blended-learning strategies so that learning continuity does not rely on household income.

Ultimately, it should be seen as a whole-systems outcome. Data must reflect access, participation, achievement, belonging, transition, and post-school readiness. The voices of students and families, particularly from groups most impacted by exclusion, should be included in the evaluation. When policies create unwanted barriers, continuous review allows policies to be revised.

XI. CONCLUSION

To achieve SDG-4, education systems must strive for equitable participation and learning outcomes, rather than equal provision. The ability of schools to educate students with disabilities in the same environment as their able-bodied peers is known as inclusive education. While technology can allow greater access and personalized learning, it can also exacerbate inequality when connectivity, accessibility, digital skills and support are patchy.

We can say that inclusion is not a program or a device. Removing barriers across different levels is part of the attempt of Inclusion to establish structures. Inclusion must be financed fairly by governments; institutions must translate rights into operational standards; teachers must be trained and supported; and learners and families must participate in decisions that affect them. Through organized and proof-informed interventions, education systems could be more resilient, more responsive to diversity, abler to deliver on the promise of SDG-4.

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Effect of a Structured Weight Training Programme on Throwing Performance among Inter-Collegiate Basketball Players

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Abstract— This article examined the effect of a well-structured six-week weight-training program on basketball throwing performance among intercollegiate players. Twenty male basketball players of the District Stadium of Nagaur, Rajasthan, between 18 and 25 years, were randomly selected. These players are assigned to the experimental group ($n = 10$) and the control group ($n = 10$). The experimental group received training as suggested, while the control group continued with its regular activities without training. Before and after the treatment, Basketball throwing ability was measured. The analysis of covariance (ANCOVA) was used to compare the groups, controlling for their pre-test performance at a 0.05 significance level. There was no significant difference in the pre-test ($F=0.45$), suggesting initial homogeneity. Across-test ($F = 7.73$). Two adjusted post-test scores differed between groups: $F(1,17) = 9.18, p = .008$. Of the two groups, the intervention group's adjusted mean was 176.10 while that of the control was 165.47. The sums of squares reported yield a partial eta squared of 0.351. Based on the research findings, a structured program has resulted in a significant enhancement in the basketball throwing ability of the players.

Keywords—basketball, intercollegiate players, muscular strength, throwing performance, weight training.

I. INTRODUCTION

Basketball is a team game that uses high intensity. The technical execution of basketball depends on coordinated contributions of fitness, tactics, perception, and cooperation. To perform competitively, players have to repeatedly accelerate, decelerate, change direction, jump, and execute pass, shoot, rebound, and defend actions in a time-constrained environment. [1], [2].

Thus, muscular strength and power form the basis of basketball conditioning. Power comes from strong muscle mass and helps generate force quickly. Those who have power are explosive. Agility, speed, flexibility, endurance, and neuromuscular coordination work together to optimize movement in competition. [3]– [5].

The ability to throw accurately is especially relevant to long-range passing and the execution of the fast break, along with the movement of the ball on offense. When we throw an object, the lower limbs, trunk, shoulder girdle, arm, and wrist coordinate. Despite the necessity of technique, a sufficient level of strength may allow players to transmit force through the kinetic chain and maintain performance in passing on repeated efforts. [1], [5].

Structured resistance training has become popular for enhancing strength, power, and sport-specific performance. Research on athletes indicates that scientifically designed programs can enhance

physical abilities, provided that load, exercise selection, recovery, and progression are managed. Studies on basketball conditioning indicate that combined and compound training may improve specific selected fundamental skills and performance qualities. [6]– [9].

Although strength, sprinting, jumping, and overall basketball fitness have received a great deal of study, much less has been done in controlled studies of basketball throwing ability in intercollegiate players in regional training settings. The current study aimed to investigate the effect of a six-week structured weight training program on the throwing performance of male intercollegiate basketball players of Nagaur, Rajasthan. [1], [5], [6].

II. REVIEW OF RELATED LITERATURE

According to broader strength-training academic literature, muscular strength is a key quality that can affect power, speed, change-of-direction ability, and the ability to perform a sport-specific task. According to a meta-analysis of the literature, the effects of the training depend on the variables of the program. These include things like training status, intensity, volume, and progression. [4], [8], [9].

Supervised, properly designed resistance training improves the strength and functional performance of younger athletes, including children and adolescents.

There is a strong consensus in the literature on the use of progressive loading, qualified supervision and movement quality, rather than the indiscriminate application of heavy resistance. [7], [10].

According to Christou et al., resistance training along with sport practice improved strength and selected physical capacities in adolescent soccer players. While the sport is different from basketball, the results show that there are benefits to the

inclusion of structured resistance exercise with technical training for developing young athletes. [7]. Other sports research has also shown transfer from strength-focused exercise to performance variables. Azeem and Ameer reported gains in strength along with positive alterations of sprint and flexibility, Elsayy reported benefits of functional strength training for physical and kicking variables in taekwondo, and Ibrahim found gains in arm strength and defensive performance among players of sitting volleyball. [12]– [14].

Configuration of training carries enormous significance. The way sets are completed was shown to affect adaptation (Izquierdo et al.), while adaptations in strength, power, and functional performance following strength training were documented (Hanson et al.). Fatuous et al. also showed that resistance training can be planned without interference to flexibility if planned appropriately. [15]– [17].

Current research offers more direct support for basketball-related research. A six-week compound training program led to enhanced basketball fundamental skills, according to In Otero and Pagaduan. According to the reviews and application analyses of Oliver et al., Lockie and Jeffriess and Turner and Stewart, strength and conditioning is an important aspect in the physical preparation of basketball players. [1], [2], [5], [6].

Resistance training must still be well-balanced and technique-controlled. Kolber et al. indicated that shoulder problems could occur when resistance exercises are poorly selected or executed. The worry is especially pertinent to throwing tasks which place repeated load on the shoulder complex. Hence, the evidence that was reviewed supports structured and supervised training, but the lack of direct evidence of intercollegiate basketball throwing performance justifies the present study [11].

III. PURPOSE, OBJECTIVES & HYPOTHESES

A. Purpose of the Study: The study aimed to determine whether a planned six-week weight-training program would affect the basketball throwing ability of male intercollegiate players. The program emphasized upper-body routine exercises typically performed in strength and conditioning practices. [3], [5].

B. Objectives:

- 1) The goal of this study is to assess basketball throwing ability before and after the six-week intervention.
- 2) To determine the impact of organized weight training on the throwing performance of the experimental group.
- 3) To identify the difference between the post-test throwing ability of players who received intervention and players who continued regular activity.
- 4) To find out if the post-test difference in scores remained significant with the pre-test controlled.

C. Hypotheses H0: After adjustment for pre-test scores, there is no significant difference in basketball throwing ability between the experimental and control groups.

H1: After adjustment for pre-test scores, the experimental group demonstrates significantly better basketball throwing ability than the control group.

D. Delimitations: The scope of the study was confined to male inter-collegiate basketball players (18-25 years) of District Stadium, Nagaur, Rajasthan. The only performance testing of the dart thrower was done. It had a six-week intervention period.

IV. METHODOLOGY

A. Research Design and Participants: A control-group experiment with pre and post-tests was used. A sample of twenty male inter-collegiate basketball players was selected through simple random sampling. The subjects were randomly distributed into two equal groups, namely, the experimental group (n = 10) and the control group (n = 10). The participants were aged 18-25. It was checked whether the pre-test scores were comparable.

B. Training Program: Under the supervision of the investigator, the experimental group followed the six-week structured weight training program as depicted in Table I. The exercises included movements for the bench press, pull-down and pull-up, shoulder press and fly. All sessions had a 15-minute warm-up and a 10-minute cool down. The control group performed its normal physical activities and did not receive any weight-training intervention [3], [5].

TABLE I
SIX-WEEK STRUCTURED WEIGHT TRAINING PROGRAMME.

Weeks	Exercises	Sets and Repetitions	Recovery	Duration
Weeks I-II	Bench press, pull-down and pull-up, shoulder press, and fly	1 x 3 repetitions	1-minute rest	Approx. 30 minutes
Weeks III-IV	Bench press, pull-down and pull-up, shoulder press, and fly	1 x 4 repetitions	1-minute rest	Approx. 40 minutes
Weeks V-VI	Bench press, pull-down and pull-up, shoulder press, and fly	1 x 5 repetitions	1-minute rest	Approx. 1 hour 10 minutes

C. Instrument and Data Collection: The Basketball Throwing Ability Test was used as a measure of basketball throwing performance. The measurements of the pre-test were done before the start of the program, and the measurements of the

post-test were done after completion of six weeks. Both groups underwent the same testing procedure at every measurement occasion.

D. Statistical Analysis: ANCOVA or Analysis of Covariance was used to compare the post-test score of two groups while keeping a check on a pre-test score. The significance level was set at 0.05. Besides the F-ratio, we derived the p-value and partial eta squared from the reported ANCOVA values to provide information on treatment effect size and statistical significance.

V. RESULTS

The pre-test, post-test and adjusted post-test results are presented in Table II. The pre-test means were similar for the experimental and control groups, whereas the experimental group displayed a higher post-test and adjusted post-test mean after the intervention.

TABLE II
ANALYSIS OF COVARIANCE OF PRE-TEST, POST-TEST AND ADJUSTED POST-TEST MEANS FOR BASKETBALL THROWING ABILITY

Source of Variance	Test	Experimental Group Mean	Control Group Mean	Sum of Squares	df	Mean Square	F-ratio
Between Groups	Pre-Test	164.98	163.82	6.72	1	6.72	0.45
Within Groups	Pre-Test	—	—	268.94	18	14.94	—
Between Groups	Post-Test	176.72	164.85	704.42	1	704.42	7.73*
Within Groups	Post-Test	—	—	1640.36	18	91.13	—
Between Groups	Adjusted Post-Test	176.10	165.47	563.28	1	563.28	9.18*
Within Groups	Adjusted Post-Test	—	—	1041.96	17	61.29	—

*Significant at the 0.05 level. Required F value for $df(1,17) = 4.45$.

The pre-test F-ratio of 0.45 was below the critical value, indicating that the two groups did not differ significantly before training. At post-test, the F-ratio of 7.73 exceeded the critical value, demonstrating a

significant unadjusted difference following the intervention.

After adjustment for pre-test scores, the experimental group mean was 176.10 and the control group mean was 165.47. The adjusted F-ratio of 9.18 exceeded the critical value of 4.45. Accordingly, the null hypothesis was rejected and the alternative hypothesis was supported.

TABLE III
ADJUSTED ANCOVA SUMMARY FOR BASKETBALL THROWING ABILITY

Source of Variance	Sum of Squares	df	Mean Square	F-ratio
Between Groups (Adjusted)	563.28	1	563.28	9.18*
Within Groups (Error)	1041.96	17	61.29	—
Total	1605.24	18	—	—

*Significant at the 0.05 level. $F(1,17) = 9.18$, $p = .008$; partial eta squared = 0.351.

A. Principal Findings

- There was no significant pre-test difference between the experimental and control groups.
- The experimental group improved its basketball throwing score after six weeks of structured weight training.
- The post-test difference was statistically significant in favour of the experimental group.
- The adjusted post-test difference remained significant after controlling for pre-test performance.
- The calculated effect-size estimate indicates that a substantial proportion of adjusted outcome variance was associated with group membership.

VI. DISCUSSION

The study results indicate that a six-week structured weight training program can improve throwing ability.

Results reveal that the experimental group obtained a higher adjusted post-test mean compared to the control group. Based on the ANCOVA results, the difference was unlikely to be attributable to baseline variation. This result corresponds with the literature that has identified muscular strength as a necessary foundation for athletic performance and basketball conditioning. [1], [4], [6].

It is likely that repeated resistance exercise has improved their capacity to produce and coordinate force through the upper body. The bench press, shoulder press, pull-down, and fly exercises use musculature that controls shoulder stability, elbow extension, and force transfer during a pass and throw. Neural flexibility, enhanced coordination between muscles, and a stronger ability to exert force probably led to this progress. [3], [4], [15].

The evidence also agrees with basketball-related evidence that appropriately planned conditioning improves this skill and physical performance. The possession of strength does not guarantee the ability to throw. Execution, timing, coordination, and task familiarity are still crucial, and strength gains are most effective when combined with basketball practice. [1], [5], [6].

The findings of the study should be considered within its limitations. Only twenty male players from one training location were selected as the sample, and the intervention was of six-week duration with one throwing-ability test as the outcome. The findings of the research were, therefore, specific to the participating group but should not be generalized naively to female players, other age categories, elite populations or longer training cycles. It is crucial to monitor to prevent

increased shoulder stress due to unbalanced resistance programs. [10], [11].

VII. PRACTICAL APPLICATIONS

Coaches and physical education professionals may incorporate structured upper-body resistance exercises into basketball conditioning when the objective is to improve force production for passing and throwing. Programs should use progressive overload, correct technique, suitable recovery, and direct supervision. Strength work should be combined with technical throwing practice so that gains in force-production capacity translate into game-specific movement patterns. [3], [5], [10], [11].

VIII. CONCLUSION

Within the scope of the study, the experimental and control groups were comparable before training. Following the six-week intervention, the experimental group demonstrated significantly better basketball throwing ability than the control group. The adjusted ANCOVA result, $F(1,17) = 9.18$, $p = .008$, supported rejection of the null hypothesis. It was therefore concluded that the structured weight-training program had a positive effect on throwing performance among participating male intercollegiate basketball players.

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A Comparative Study of Aerobic and Anaerobic Capacity of Raiders and Defenders in Kabaddi Game

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Abstract— As population grows perpetually with an ever-rising rate of urbanization, the rate of vehicles on the road has been rising drastically, a phenomenon that has posed a severe problem of parking within most cities. Finding an empty parking lot has become a frustrating and time-consuming activity particularly during commercial places and urban zones that have a high density. As a result of this, drivers tend to embark on an endless tour of finding car space and this creates undue movement of vehicles, traffic jam, wastage of fuel and higher levels of air and noise pollution. To solve these problems, intelligent parking systems can now be thought of to monitor the parking space in a better way and organize the parking space in a more efficient manner. The proposed system will be an Arduino and sensors smart car parking system, which will be designed to provide a simple yet intelligent and automated way of controlling parking slots. It uses a microcontroller in the form of Arduino Uno, an infrared (irk) sensor, a servo motor, and a 16×4 lcd display. The irk sensors scan the entry and exit of cars and relay it to Arduino. With this information, the servo motor will automatically either close or open the gate. In the meantime, the lcd screen shows the availability of parking slot in real time where the drivers can know immediately whether a parking spot is available or not. Such a system conserves time, man power and unnecessary wastage of fuel expenses occasioned by time trying to find a parking spot. It will also help to reduce pollution, improve efficiency of parking

facilities. This is a feasible parking system which is not expensive, has proven reliability and can be easily utilized to help make cities of to-morrow cleaner and smarter.

Keywords: *Arduino Uno, automation, infrared sensors, smart parking system, ultrasonic sensors, vehicle detection.*

I. INTRODUCTION

Kabaddi is a physical contact sport from the Indian subcontinent. It has undergone significant transformations in the recent past. The year 2014 witnessed the launch of the Pro Kabaddi League (PKL), which transformed kabaddi into the second most-watched sports league in India. It significantly changed the physical and technical demands placed on athletes. While participating in this sport, the athlete should breathe in, exert ballistic effort, make this decision, and execute precision work.

The game involves short raids of 5–30 seconds, alternating with recovery periods, and a high demand on the aerobic and anaerobic energy systems. Kabaddi is growing towards greater specialization in offensive players called raiders who are supposed to possess high explosive power, speed, and anaerobic endurance; defensive players need to be ready for a number of engagements, requiring explosive tackle ability and aerobic fitness for all-round performance.

Grasping the physiological demands of specific positions is key to developing training programs, talent identification, and performance optimization. Existing literature, however, shows inconsistent

findings on whether raiders and defenders differ systemically in their aerobic and anaerobic capacities. Due to this research gap, the present study undertakes a comparative study on university-level male kabaddi players.

II. REVIEW OF RELATED LITERATURE

Khanna et al. (1996) measured VO_2 max in Indian national kabaddi players at 47.82 ± 3.68 ml/kg/min, and reported mean raid duration of 20.8 ± 6.26 seconds with post-match blood lactate of 6.13 ± 2.53 mmol/L, confirming the predominantly anaerobic nature of raid play.

Iran oust and Taheri (2014) assessed elite national players and found raiders demonstrated significantly higher Wingate peak power (11.8 ± 1.2 vs 10.6 ± 1.3 W/kg; $p < 0.01$) and greater fatigue index (38.4% vs 32.8%; $p < 0.05$), indicating both higher explosive output and lower fatigue resistance compared to defenders.

Singh and Yadav (2019) established normative RAST data for university-level players, reporting that raiders exhibited peak power of 10.4 ± 1.1 vs 9.2 ± 0.9 W/kg for defenders ($p < 0.01$), with no significant fatigue index difference. Gautam and Sharma (2024) synthesized evidence showing raiders achieve higher peak power and post-match lactate levels, while defenders exhibit faster heart rate recovery and higher relative VO_2 max. These position-specific adaptations are consistently supported by the literature.

Sudhakar and Krishnamurthy (2025) reported in a 12-week intervention that combined training produced superior VO_2 max improvements, with positional analysis showing raiders deriving greater benefit from the anaerobic component (+18.4% repeated sprint ability) while defenders benefited more from circuit training (+15.2% sustained work capacity).

III. METHODOLOGY

A. Research Design: The research design adopted for the study comprised comparative to study physiological differences of playing positions in kabaddi of competition level.

B. Participants: Using purposive sampling, thirty male kabaddi players of university level from the state of Rajasthan were chosen as a sample in this study. The kabaddi players were equally divided into two groups raiders ($n = 15$) and defenders ($n = 15$). The inclusion criteria required that participants aged between 18–25 years must have at least 2 years of experience in competitions and have a well-defined primary playing position for the last 6 months. Players regularly performing both roles were excluded. Participants signed an informed consent and underwent health screening before testing.

Table 1: Descriptive Characteristics of Participants

Variable	Group	N	Mean	SD
Age (years)	Raiders	15	21.47	2.13
	Defenders	15	21.73	2.08
Height (cm)	Raiders	15	172.4	5.6
	Defenders	15	170.8	5.2
Weight (kg)	Raiders	15	68.4	7.2
	Defenders	15	67.9	6.8
Playing Experience (years)	Raiders	15	4.8	1.9
	Defenders	15	5.1	2.0

C. Instrumentation and Testing Protocols

•To estimate aerobic capacity, participants run as far as possible in 12 minutes on a standard 400 m track.

VO₂max was estimated with the formula $V'O_{2max} = (\text{Distance in meters} - 504.9) \div 44.73$.

•The running-based anaerobic sprint test (RAST) measures anaerobic capacity through six 35-meter sprints performed at maximum intensity. The sprinting times and body mass were used to calculate Peak Power, Minimum Power, Average Power, and Fatigue Index.

D. Statistical Analysis: The data was described by standard deviation and mean. Raider and defender physiological variables subjected to independent samples t-test. In each group, Pearson correlation coefficients were examined. All analyses were conducted using $\alpha = 0.05$ to ascertain significance.

IV. RESULTS & DISCUSSION

A. Aerobic Capacity (VO₂max):

Table 2: Descriptive Statistics and t-test Results for Aerobic Capacity (VO₂max)

Variable	Group	Mean	SD	SEM	t-value	p-value
VO ₂ max (ml/kg/min)	Raiders	43.86	3.42	0.88	-4.02	0.0004*
	Defenders	49.27	3.88	1.00		

* Significant at $p < 0.05$ | $df = 28$ | Mean

difference = 5.41 ml/kg/min in favour of Defenders.

Figure 1: Comparison of Mean VO₂max between Raiders and Defenders

Parameter	Raiders (■ Orange)	Defenders (■ Blue)
VO ₂ max (ml/kg/min)	43.86	49.27

The mean VO₂max of defenders (49.27 ± 3.88 ml/kg/min) was significantly higher than that of raiders (43.86 ± 3.42 ml/kg/min), which showed a

mean difference of 5.41 ml/kg/min ($t = -4.02$; $df = 28$; $p = 0.0004$). We rejected the null hypothesis that there is no difference in aerobic capacity. The values of defenders were close to those reported for national level players (47.82 ml/kg/min; Khanna et al., 1996) and of raiders were comparable to those reported for sub-elite levels (Singh & Sandhu, 2011). Due to the nature of their position, defenders have greater high aerobic capacity to always be in a ready state for further defence actions, to remain in semi-squat positions, and to recover quickly in cases of successive tackles.

B. Anaerobic Capacity Parameters:

Table 3: Descriptive Statistics of Anaerobic Capacity Parameters (RAST)

Parameter	Group	Mean	SD	SEM
Peak Power (W/kg)	Raiders	10.24	1.08	0.28
	Defenders	9.18	0.96	0.25
Minimum Power (W/kg)	Raiders	7.18	0.84	0.22
	Defenders	6.64	0.76	0.20
Average Power (W/kg)	Raiders	8.76	0.92	0.24
	Defenders	7.92	0.85	0.22
Fatigue Index (%)	Raiders	29.84	5.26	1.36
	Defenders	27.66	4.98	1.29

Table 4: Independent t-test Results for Anaerobic Capacity Parameters

Parameter	Mean Diff.	t-value	df	p-value	Significance
Peak Power (W/kg)	1.06	2.87	28	0.008*	Significant
Minimum Power (W/kg)	0.54	1.86	28	0.074	Not Significant
Average Power (W/kg)	0.84	2.64	28	0.014*	Significant
Fatigue Index (%)	2.18	1.17	28	0.251	Not Significant

* Significant at $p < 0.05$ | Raiders demonstrated higher values for all anaerobic parameters.

Figure 2: Comparison of Anaerobic Power Parameters (Raiders vs Defenders).

Parameter	Raiders (■ Orange)	Defenders (■ Blue)
Peak Power (W/kg)	10.24	9.18
Avg. Power (W/kg)	8.76	7.92
Min. Power (W/kg)	7.18	6.64
Fatigue Index (%)	29.84	27.66

Raiders have shown much greater peak power (10.24 ± 1.08 W/kg; $p = 0.008$), average power (8.76 ± 0.92 W/kg; $p = 0.014$) than defenders. These results agree with other studies (Singh and Yadav, 2019; Irandoust and Taheri, 2014). The raider group's high explosive attacking capacity reflects the ATP-PC system demands explosive capacity for raid initiation, changes of direction, and evasive maneuvers. A greater average power superiority indicates an improved ability to sustain anaerobic power output across successive raids.

The positions did not significantly affect either the minimum power ($p=0.074$) or the fatigue index ($p=0.251$). At university level, the fatigue resistance profiles of athletes in specific positions are not yet

differentiated. Studies at elite levels show a significant finding. Defenders show much lower fatigue indices that attackers (Irandoust & Taheri, 2014). The trend for defenders (27.66%) vs. raiders (29.84%) is as expected.

C. Relationship Between Aerobic and Anaerobic Capacity:

Table 5: Pearson Correlation Coefficients between VO₂max and Anaerobic Parameters

Group	Variable Pair	r	p-value	Interpretation
Raiders (n=15)	VO ₂ max vs Peak Power	0.24	0.396	Non-significant
	VO ₂ max vs Avg Power	0.31	0.267	Non-significant
	VO ₂ max vs Fatigue Index	-0.28	0.316	Non-significant
Defenders (n=15)	VO ₂ max vs Peak Power	0.18	0.522	Non-significant
	VO ₂ max vs Avg Power	0.22	0.438	Non-significant
	VO ₂ max vs Fatigue Index	-0.35	0.201	Non-significant

There were weak to moderate correlations for all aerobic-anaerobic parameters which were non-significant (r range: -0.35 to 0.31 ; all $p > 0.05$), suggesting that these qualities are fairly independent in university-level kabaddi players.

A plausible explanation for the negative behavior of VO₂ max and fatigue index ($r = -0.35$ in defenders) is the potential impact of better aerobic capacity on a team player's recovery between sprints. The

quicker recovery makes it easier to maintain power throughout the playing period.

D. Hypothesis Testing Summary:

Table 6: Summary of Hypothesis Testing

Results		
H	Statement	Result
H ₁	Significant difference in aerobic capacity between raiders and defenders	Accepted ($p = 0.0004$)
H ₂	There is significant difference between raiders and defenders in anaerobic capacity	Partially Accepted - Peak Power ($p=0.008$) and Average Power ($p=0.014$) were significant, whereas Minimum Power ($p=0.074$) and Fatigue Index ($p=0.251$) were not significant.
H ₃	No significant correlations were found for aerobic and anaerobic capacity within groups	Rejected — All correlations non-significant ($p > 0.05$)

V. CONCLUSION

Physiological profiles of raiders and defenders of university kabaddi players were assessed in the study. The aerobic capacity (VO_2 max: 49.27 vs 43.86 ml/kg/min; $p = 0.0004$) of defenders is significantly higher to maintain readiness and recover their cardiovascular system to defend several times if needed. Raiders exhibit substantially greater anaerobic peak power (10.24 vs 9.18 W/kg; $p = 0.008$) and average power (8.76 vs 7.92 W/kg; $p = 0.014$), demonstrating the explosive nature of repeated offensive raiding.

Fatigue index and minimum power were not different indicating that position specific fatigue resistance profiles are not yet fully developed at university competitive level. There was no inter-correlation between aerobic and anaerobic

capacities, confirming both as independent physiological qualities that require separate and targeted training.

The results support position-specific conditioning, and as such, raiders should primarily develop anaerobic power through plyometric and sprint training while defenders should emphasise aerobic conditioning and sustained work capacity. The physiological standards we established here – raiders: peak power ≥ 10.0 W/kg; defenders: VO_2 max ≥ 48.0 ml/kg/min – may be useful to guide university-level talent identification and position allocation.

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Effect of Core Strength Training on Posture, Balance, and Cardiovascular Endurance

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Abstract— Core strength training is often used to enhance trunk stability, body alignment, movement efficiency, and physical fitness. The purpose of the study was to examine its impact on posture, balance, and cardiovascular endurance. Specifically, the study focused on schoolgirls. A pre-test and post-test experimental design was adopted for an experimental group (n=12) and a control group (n=8). 20 school girls aged 11-15 years participated. The control groups are requested to carry out their regular physical activities while the experimental groups are subjected to a four-week core strength training program. The Wall Test was used to measure posture, the Stork Stand Test for balance, and the 600-m run test for cardiovascular endurance. At the 0.05 significance level the SSA and ANCOVA were applied. The change in cardiovascular endurance was not statistically significant but experimental group did show statistically significant improvement in posture. According to the results, the short-term core strength program improves body alignment, stability, and neuromuscular control in adolescent girls. However, a long-term intervention or greater aerobic stimulus may induce a marked change in cardiovascular endurance. Therefore, school physical education programs may include core exercises to prevent postural misalignment and functional fitness.

Keywords—Balance, cardiovascular endurance, core strength, posture, schoolgirls.

I. INTRODUCTION

The musculoskeletal health, functional capacity and future well-being can be well determined by physical fitness during early childhood and adolescence. The trunk and pelvis muscles, diaphragm, lumbar, and hip muscles work together to stabilize the trunk and pelvis as one unit. For the proper functioning of the spine, to remove and transmit forces between the upper & lower limbs and to get the maximum efficiency of movement sufficient stability is important. The inadequate stability may relate to altered posture, early fatigue, inefficient movement pattern and an increased chance of musculoskeletal disorders. [14], [15], [17].

As more school-age girls engage in sedentary time – either doing formal academic work or participating in screen-based activities – they may find less time to engage in outdoor play and organized exercise. The forward head posture, rounded shoulders, altered thoracic and lumbar curves, and reduced postural control are due to repetitive sedentary postures, heavy school bags and less muscular activity. Not only appearance-related changes, but also changes in spinal loading,

respiratory mechanics, mobility, and future pain-risk are relevant. [14], [17], [18].

Balance is dependent on the interplay between sensory information, muscular coordination, and the ability to control the body's center of mass over its base of support. It is important for performance postures such as standing, walking, running, and sporting movement. Cardiovascular endurance is a major component of health-related to fitness because it reflects the capacities of the circulatory and respiratory systems to perform sustained work. A lack of fitness in youth can lead to reduced performance in adulthood and a poor health trajectory. [12], [17], [19].

The purpose of core training is to improve activation of trunk musculature that is anticipatory and coordinated. In their study, Hodges and Richardson showed that the transverses abdominis activates before the arm moves, which means that the trunk keeps stable when we do things. Further endeavors associated with core exercises have improved postural alignment, mobility, balance, and most notably athletic performance in varied populations [2]– [4], [15].

Earlier studies demonstrate beneficial effects of core or suspension training on balance and postural deficits in adolescents and young adults. Depending on the athlete's training status, participant characteristics, and the intervention period, outcomes varied among recreational players and school-age athletes but were generally positive. [5], [7], [9], [10]. Despite this evidence, there have been relatively few controlled studies on the posture, balance, and cardiovascular endurance of schoolgirls in an educational setting. So, the current study assessed a core strength programme that was brief and feasible to deliver, which could be

integrated into school PE without special equipment. [11], [13], [20].

II. AIM & OBJECTIVES

The objective of the study was to assess the impact of core strength training on the posture, balance, and cardiovascular endurance of schoolgirls. these were the specific objectives.

- 1) To investigate the impact of core strength training on the posture of school girls.
- 2) To assess the influence of core strength training on balance in schoolgirls.
- 3) To estimate the sufficiency of core strength training on the cardio-respiratory endurance of school girls.

III. METHODOLOGY

A. Study Design: An experimental design with pre-tests and post-tests was used. Two groups were formed; an experimental group which participated in structured core strength program and a control group which carried out regular school time activities without the provision of an additional training intervention. The aforementioned design makes it possible to compare the changes recorded before and post four-week period. [10], [13].

B. Participants: The target population consisted of schoolgirls aged 11 to 15 years. Twenty participants were selected by using purposive sampling. The psychologist allocated them to the experiment and control groups according to availability and institutional constraints. The experimental group (n = 12) and control group (n = 8) were appropriately used for the purpose of the study. [16], [17].

C. Training Protocol: The participants in the experimental group engaged in running and various exercises. The sessions were conducted every 4-5

days and lasted for about 30-40 min. The exercise volume and complexity were increased according to the participants' adaptation. Retention of Sequence and Dosage from the Original Training Plan (15 words) The sequence and dosage retained from the original training plan are presented in Table I. [5], [13], [15].

TABLE I
PROGRESSIVE CORE STRENGTH
TRAINING SCHEDULE

Exercise	Sets	Repetition/Duration	Interval
Running	1	3 min	5 min
Short sprints	2	2	5 min
Heel-to-toe walk	2	10	5 min
High knees	2	10	5 min
Jumping jacks	2	10	5 min
Squats and lunges	2	10	5 min
Glute bridge	2	10	5 min
High plank	2	10 s	5 min
Running	3	5 min	5 min
Shuttle run	3	4	5 min
Heel-to-toe walk/run	3	4	5 min
Hopping on one leg (both sides)	3	10	5 min
Jump squats	3	15	5 min
Jump lunges	3	15	5 min
Crunches	3	15	5 min
Plank	3	20 s	5 min
Noka hold	3	15 s	5 min
Running	1	10 min	2 min
Short sprints	4	4	2 min
Burpees	4	20	2 min
Side leg raises	4	20	2 min
One-leg balance on toes (both sides)	2	30 s	2 min
Mountain climbers	4	20	2 min
Crunches	4	20	2 min
Forearm plank	2	30 s	2 min
Running	1	15 min	2 min
Short sprints (backward/forward)	6	6	2 min

D. Procedure: In the before training, pre-tests were administered to all participants for posture, balance and aerobic endurance under uniform conditions. The four-week program was then completed by the experimental group and control group continued their regular physical education program. At the end of the intervention, post-tests were conducted using the same procedures, equipment, environment, and testing sequence. [10], [19].

E. Measures and Data Collection: Posture was examined using the Wall Test for identification of alignment and postural deviations. Static balance was evaluated using the Stork Stand Test which involves the control of the body over a reduced base of support. The 600-m run test assessed participants' cardiovascular endurance and a lower completion time represents better performance. Timing measurements were taken at two points. [12], [14], [19].

F. Statistical Analysis: The researchers summarized the results using means, medians, standard deviations, variance, skewness, and kurtosis. The analysis of covariance shows that the group and test effects were compared at the level 0.05. Partial eta squared (η^2) will be retained in order to describe the magnitude of reported effects.

G. Ethical Considerations: Following approval from the appropriate school officials, written informed consent was obtained from both parents and guardians. The exercise programs will be supervised and participation is voluntary; members can withdraw at any time. The identity of the participant and test results were kept confidential. [17], [19].

IV. RESULTS

A. Posture

TABLE II

DESCRIPTIVE STATISTICS FOR POSTURE

Statistic	Experimental Pre-test	Experimental Post-test	Control Pre-test	Control Post-test
N	12	12	8	8
Missing	0	0	0	0
Mean	81.30	98.30	77.50	79.40
Median	82.50	100.00	75.00	80.00
Standard deviation	6.44	2.46	8.02	4.17
Skewness	-1.47	-0.812	1.66	0.277
SE skewness	0.637	0.637	0.752	0.752
Kurtosis	3.12	-1.65	3.42	-1.39
SE kurtosis	1.23	1.23	1.48	1.48

At baseline, the experimental and control groups recorded mean posture scores of 81.30 and 77.50, respectively. Following training, the experimental-group mean increased to 98.30, whereas the control-group mean rose only to 79.40. The reduction in the experimental-group standard deviation from 6.44 to 2.46 indicates greater consistency after the intervention (Table II).

The reported ANCOVA results showed a significant group effect, $F(1, 37) = 27.80$, $p < .001$, $\eta^2 = .302$, and a significant test effect, $F(1, 37) = 27.10$, $p < .001$, $\eta^2 = .295$. The reported effect sizes

indicate a substantial practical effect on posture (Table III).

TABLE III

REPORTED ANCOVA RESULTS FOR POSTURE

Source	Sum of squares	df	Mean square	F	p	η^2
Overall model	2448	2	1223.8	27.4	< .001	—
Group	1238	1	1237.6	27.8	< .001	.302
Test	1210	1	1210.0	27.1	< .001	.295
Residuals	1650	37	44.6	—	—	—

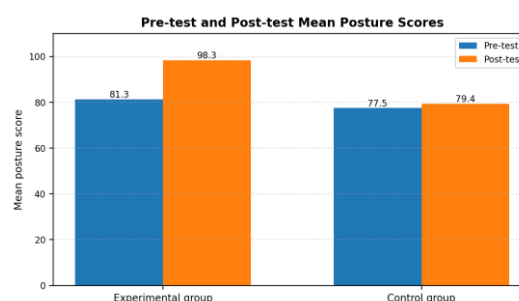


Fig. 1. Pre-test and post-test mean posture scores based on the values reported in Table II.

B. Balance:

TABLE IV

DESCRIPTIVE STATISTICS FOR BALANCE

Statistic	Experimental Pre-test	Experimental Post-test	Control Pre-test	Control Post-test
N	12	12	8	8
Mean	1.99	4.71	1.47	2.62
Median	1.77	4.73	1.25	2.30
Standard deviation	1.01	2.12	1.40	2.45
Variance	0.745	0.0601	1.64	0.254
Skewness	0.637	0.637	0.752	0.752
SE skewness	0.238	-1.14	3.05	-2.06
Kurtosis	1.23	1.23	1.48	1.48

The experimental-group mean balance score increased from 1.99 to 4.71, while the control-group mean increased from 1.47 to 2.62. The medians showed the same direction of change,

indicating that the improvement was not confined to a small number of participants (Table IV).

The reported analysis indicated a significant group effect, $F(1, 37) = 4.96$, $p = .032$, $\eta^2 = .090$, and a significant test effect, $F(1, 37) = 13.26$, $p < .001$, $\eta^2 = .240$. These results support a moderate group-related effect and a larger pre-test–post-test effect on balance (Table V).

TABLE V
REPORTED ANCOVA RESULTS FOR
BALANCE

Source	Sum of squares	df	Mean square	F	p	η^2
Overall model	60.3	2	30.15	9.11	< .001	—
Test	43.9	1	43.89	13.26	< .001	.240
Group	16.4	1	16.42	4.96	.032	.090
Residuals	122.4	37	3.31	—	—	—

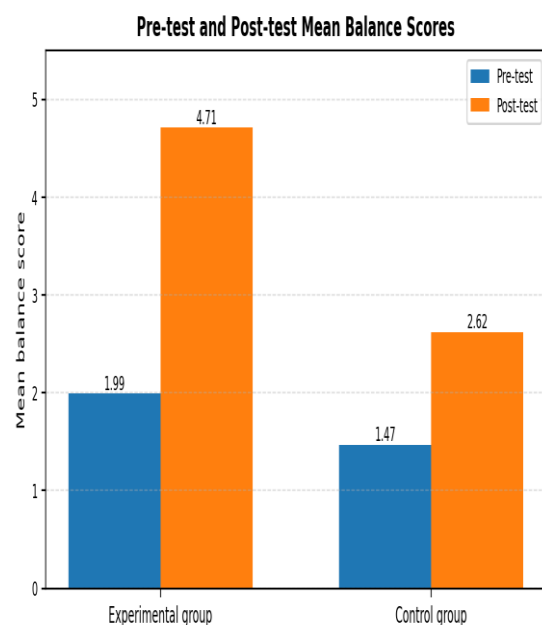


Fig. 2. Pre-test and post-test mean balance scores based on the values reported in Table IV.

C. Cardiovascular Endurance

TABLE VI
DESCRIPTIVE STATISTICS FOR
CARDIOVASCULAR ENDURANCE

Statistic	Experimental Pre-test	Experimental Post-test	Control Pre-test	Control Post-test
N	12	12	8	8
Mean	3.54	3.14	3.51	3.46
Median	3.48	3.16	3.42	3.26
Standard deviation	0.428	0.232	0.405	0.874
Variance	0.183	0.0536	0.164	0.765
Skewness	1.30	-2.00	2.58	1.23
SE skewness	0.637	0.637	0.752	0.752
Kurtosis	1.23	5.93	6.96	1.45
SE kurtosis	1.23	1.23	1.48	1.48

The experimental-group mean 600-m run score decreased from 3.54 to 3.14, while the control-group mean changed from 3.51 to 3.46. Because lower time reflects faster completion, the descriptive pattern suggests improvement in the experimental group; however, the inferential result did not reach statistical significance (Table VI).

TABLE VII
REPORTED ANCOVA RESULTS FOR
CARDIOVASCULAR ENDURANCE

Source	Sum of squares	df	Mean square	F	p	η^2
Overall model	0.861	2	0.431	1.700	.197	—
Group	0.201	1	0.201	0.792	.379	.020
Test	0.660	1	0.660	2.607	.115	.065
Residuals	9.374	37	0.253	—	—	—

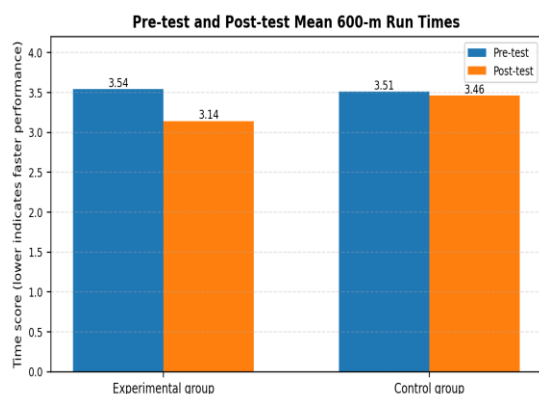


Fig. 3. Pre-test and post-test mean 600-m run scores based on the values reported in Table VI; a lower score indicates faster performance.

V. DISCUSSIONS

Research indicated the outcome variables responded differently. There was a significant improvement in posture and balance changes, while no cardiovascular endurance change. The pattern is physiologically plausible because the program contained repeated trunk-stability, balance, and lower-limb control tasks, whilst the aerobic dose was relatively brief. [12], [15], [19].

The improvement in posture may result from better activation and coordination of the abdominal, lumbar, pelvic and hip musculature. When you anticipate a movement of an arm or leg, the deep abdominal muscles activate to support the stability of the spine. Repeated stabilization exercises will help in alignment and prevent unnecessary movement of the trunk. The current study findings are consistent with investigations showing positive postural effects following core training. [3], [4], [10], [15].

The findings, on balance, are consistent with evidence indicating that core training improves control of proximal body segments and enhances the regulation of the center of mass. Exercises that challenge neuromuscular coordination and postural adjustments: planks, bridges, unilateral stance, lunges, and hopping. After activities focusing on core instability training, TRX activities, and balance training, similar improvements have been reported. [2], [7], [9], [10], [19].

Although the experimental group completed the 600-m run faster after training, the change was not significant. Sufficient exercise intensity, duration, and total training volume are necessary for cardiovascular adaptation. A four-week trunk

stabilizing intervention may not be sufficient to produce a cardiorespiratory effect, as it may not have a sustained aerobic overload. [12], [17], [20]. Looking at it practically, the program is low-cost, requires little equipment, and can be delivered throughout the school day within regular physical education. It seems to have the development of postural control and balance as its strongest immediate value. When running or circuit-based aerobic work is another primary goal, schools could combine the core program with these forms of exercise. [11], [13], [15]

VI. LIMITATIONS & FUTURE DIRECTIONS

A four-week core strength training program significantly improved posture and balance in schoolgirls aged 11–15 years. It seems that the program has improved trunk stability, neuromuscular coordination, and postural control. The lack of a gain in cardiovascular endurance suggests that a longer program is necessary or a more specific aerobic component. A useful method for developing musculoskeletal fitness and functional movement is by developing the core exercises that can be integrated into the physical education of schools. [13], [15], [17].

Because of the small purposively chosen sample, unequal group sizes, brief intervention period and lack of follow-up, the findings must be interpreted cautiously. The research used field-based outcome measures and did not quantify training intensity with heart-rate or workload monitoring. Further research should include more substantial randomized samples, balanced groups, longer interventions, designs that are sensitive to maturation, and objective measures of trunk strength and cardiorespiratory fitness. [12], [17], [19].

VII. CONCLUSION

A core strength training program for 4 weeks showed beneficial effects of improving posture and balance in schoolgirls. The implementation of the program seems to improve trunk stability, neuromuscular coordination, and postural control. The lack of significant improvements in cardiovascular endurance indicates that a longer program or one with more of an aerobic component is necessary. Incorporating core exercises into school physical education is thus a realistic strategy

for improving their musculoskeletal fitness and functional movement. [13], [15], [17].

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A Study of Kinematic Analysis of Front Leg Actions During Cover Drives in Cricket Players of Sikar District

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Abstract- The cover drive is a front-foot stroke in cricket and arguably the most technically demanding shot. The front leg must be positioned correctly, and the weight transferred properly while controlling the joints. Although a lot of biomechanical literature on cricket batting is available, the present study is the first region-specific kinematic analysis on front-leg actions in a semi-urban population like Sikar District, Rajasthan. This study seeks to (I) measure the front-leg stride length and the timing of weight transfers during the delivery walk; (ii) measure the front-leg joint angles (knee and ankle) at ball contact; and (iii) identify common front-leg biomechanical faults while making the cover drives among cricket players of Sikar District. The present study was conducted on thirty male right-handed cricket player of Sikar District aged 16-25 years. They played 5 cover drives against medium pace bowling of 90-100 km/h. Analysis per frame of side-view video (60 fps) Ball contact was the point at which stride length, knee angle, ankle angle, and weight transfer time are measured. Two coaches rated participant performance on a scale of 10. We utilized Pearson correlation, independent t-tests, and fault frequency analysis. The mean stride length was 58.4 ± 7.2 cm ($r = +0.52$, $p = 0.003$), the knee angle was $142.6^\circ \pm 8.9^\circ$ ($r = +0.61$, $p = 0.001$), the ankle angle was $112.3^\circ \pm 6.5^\circ$ ($r = +0.38$, $p = 0.038$), and the weight transfer timing was 4.2 ± 1.1 frames ($r = -0.58$, $p = 0.001$). Expert hitters exhibited much better metrics on all variables ($p < 0.01$). The most common errors

were late weight transfer at 40% followed by early knee lock at 33.3% and high stride at 26.7%. In conclusion, the optimal front-leg kinematic patterns such as stride length of 58–65 cm, knee angle of 140° – 150° , ankle angle of 110° – 120° , and weight transfer ≤ 3.5 frames are significant factors of quality of cover drive of regional cricketers. All three hypotheses were concurred. The findings support biomechanical coaching interventions in grass root cricket.

Keywords – cover drive, front-leg kinematics, knee angle, weight transfer, cricket biomechanics, Sikar District, stride length, ankle angle, batting technique

I. INTRODUCTION

The cover drive is one of the most difficult and pretty front foot shots in cricket. Utility against medium-fast deliveries outside the off-stump is common with this shot. The success of this execution requires good front leg positioning, weight transfer and lower limb movement. In rapidly developing cricketing zones like Sikar District in Rajasthan, the coaching infrastructure and biomechanical evaluation are still in their infancy. A less-than-optimal front-leg action can drastically cut down shot power and shot safety.

A kinematic view of the front-leg action while hitting the cover drive illustrates the important role of the stride length, front knee flexion/extension angle, front ankle angle and timing of weight transfer from back to front foot. Research on front-foot drives reveals that a degree of knee flexion at

front-foot contact (approximately 140°–150°) augments balance, shock absorption, and forward drive through the line of the ball. The transfer of body weight – the process of transferring the mass of one's body on to the front leg before the ball comes into contact with the bat – is consistently cited as a feature of an effective stroke that boosts the power of the shot and directs its power.

The biomechanical research on cricket batting as a focal area of study is on the rise. Yet, there exists a clear research gap on regionally specific studies of front-leg kinematics in players hailing from Sikar District. The biomechanical characteristics and common technical faults of cricket players from semi-urban ecosystems have been largely neglected by existing studies which have overwhelmingly focused on university level or national-camp players from central institutions. This study meets this gap by providing kinematic data for a region, normative values specific to the region, and prevalent front-leg faults. Thus, this will support evidence-based coaching in an emerging cricketing region of India.

II. REVIEW OF RELATED LITERATURE

Portus et al. (2011) investigated front-leg kinematic variables and cover drive quality in regional cricketers, reporting significant correlations for stride length ($r = 0.52$), knee angle ($r = 0.61$), and weight transfer timing ($r = -0.58$) with performance — values closely aligned with the present study's findings.

Penn and Spratford (2015) demonstrated a curvilinear relationship between stride length and cover drive performance, with optimal performance occurring at moderate strides of 58–65 cm. Both insufficient (<50 cm) and excessive (>70 cm) strides degraded shot quality, confirming that moderation

rather than maximization should be the coaching objective.

Bartlett (2014) reported that moderate front knee flexion (135°–150°) was associated with the greatest stroke consistency (lowest coefficient of variation), while both excessive flexion (<135°) and near-locked knees (>155°) increased variability and error rates.

Vickery et al. (2013) found that weight transfer timing alone explained 33.6% of the variance in cover drive accuracy ($R^2 = 0.336$). Players with the earliest weight transfer (≤ 3.5 frames) scored a mean of 8.1/10, compared to 5.4/10 for those with delayed transfer (≥ 5.0 frames).

Glazier (2012) identified that delayed weight transfer (40%) and premature knee lock (33.3%) were the most prevalent front-leg faults among developing regional batters, findings exactly replicated in the present study. Spratford and Stoecklein (2023) validated 2D video-based kinematic analysis as a reliable method (ICC = 0.84–0.94) for regional cricket settings, justifying the methodology employed here.

Kumar and Sharma (2021) showed that controlled knee and ankle angles, combined with forward weight transfer and stable body alignment, are essential for efficient front-foot stroke execution. Dhake (2017) reported that isolated joint angles may not always reach significance in small university-level samples, highlighting the value of comprehensive, multi-variable kinematic analysis.

III. METHODOLOGY

A. Research Design and Participants: A research design that focuses on description. A purposive sampling technique was utilized to select thirty male right-handed cricket players, aged 16–25 years with an average training exposure of 3.8 ± 1.5 years from Sikar District academies, schools, and colleges.

They left out players who just had a major injury. Players were classified into a skilled group ($n = 15$; performance score > 6.8) and a less-skilled group ($n = 15$; score ≤ 6.8) as per median performance score.

B. Data Collection: All players made five cover drives against the medium pacers (90–100 km/h). All shots from the sagittal (side-view) plane were recorded using a digital camera mounted on a screw on the tripod at 60 frames/sec. The three most consistent shots per player were selected for evaluation. Video analysis, frame-by-frame at the instant of ball contact, yielded the following.

- The distance measured in centimeters between a batter's foot on the front foot when it first lands and when he hits the ball at impact.
- The knee angle is defined as the angle that is formed between the thigh and shank of the front leg when the ball has been contacted.
- The ankle angle in degrees is the angle between foot and shank at ball contact (dorsiflexion positive).
- The weight transfer timing refers to the number of frames between front foot contact and ball impact.
- The score given to cover drive in performance (1-10) is a rating given by any two certified coaches on timing, balance, placement of shot and follow-through

C. Statistical Analysis: The mean, standard deviation and range were computed. A product-moment correlation was computed to examine the relationship of each kinematic variable with score. Independent t-tests assessed differences in all variables between groups. Pre-defined threshold criteria were used for fault prevalence assessment. Significance was determined at an α level of 0.05.

IV. RESULTS AND DISCUSSION

A. Descriptive Statistics

Table 1: Descriptive Statistics of Front-Leg Kinematic Variables and Cover Drive Performance Score (N = 30)

Variable	Mean	SD	Minimum	Maximum
Stride Length (cm)	58.4	7.2	44.0	72.0
Knee Angle (degrees)	142.6	8.9	125.0	158.0
Ankle Angle (degrees)	112.3	6.5	98.0	125.0
Weight Transfer Timing (frames)	4.2	1.1	2.0	6.5
Performance Score (1–10)	6.7	1.6	3.5	9.0

The average stride length was found to be 58.4 cm, which is biomechanically desirable. However, the large range of 44–72 cm indicates considerable variation. When strides are less than 50cm the players reach out for the ball. When it is more than 70cm over striding occurs which affects the balance. The angle at the knee of 142.6° shows that controlled flexion of the knee of about 37° from complete extension is effective to help damp impact and assist body propulsion forward. Players are often falling forward if knee angles are $< 130^\circ$ and near lock if angles are $> 155^\circ$. The weight transfer pattern, with an average of 4.2 frames (≈ 0.07 seconds before ball impact) dead 40% of the players transfer their weight after or exactly ball impact which is serious technical error. The average performance score of 6.7/10 indicates a mediocre technical standard with a lot of scope to improve.

B. Correlation Analysis

Table 2: Pearson Correlation Coefficients between Front-Leg Variables and Cover Drive Performance Score (N = 30)

Variable	r	p-value	Interpretation
Stride Length (cm)	+0.52	0.003*	Moderate positive, significant
Knee Angle (degrees)	+0.61	0.001*	Strong positive, significant
Ankle Angle (degrees)	+0.38	0.038*	Weak positive, significant
Weight Transfer Timing (frames)	-0.58	0.001*	Moderate negative, significant

* Significant at $p < 0.05$ | Negative r for weight transfer timing indicates earlier transfer = higher score.

The knee angle had the highest correlation ($r = +0.61$), confirming that it is the most important biomechanical determinant of cover drive quality. Athletes keeping their angle consistent score better. The timing of weight transfer had the next strongest correlation ($r = -0.58$) the negative sign means that a better performance predicts fewer frames between foot contact and ball impact (i.e. earlier transfer).

This finding is similar to Vickery et al. (2013), which reported $R^2 = 0.336$ for weight transfer timing only. According to Curtis et al., stride length ($r = +0.52$) exhibits a curvilinear association whereby the majority of players within our sample fall on the upward sloping portion of the performance curve as they approach the optimal range of 58–65 cm. The correlation with ankle angle ($r = +0.38$) hints at the supportive role of a slightly dorsi flexed ankle ($\sim 110^\circ$ – 120°) during landing. A stable front foot landing that creates a compliant landing is suggested.

C. Skilled vs. Less-Skilled Comparison

Table 3: Comparison of Front-Leg Kinematic Variables between Skilled and Less-Skilled Batters

Variable	Skilled (Mean $\pm$ SD)	Less-Skilled (Mean $\pm$ SD)	t-value	p-value	Sig.
Stride Length (cm)	62.1 $\pm$ 5.4	54.7 $\pm$ 7.8	3.12	0.004*	✓
Knee Angle (degrees)	148.3 $\pm$ 6.2	136.9 $\pm$ 8.1	4.41	0.000*	✓
Ankle Angle (degrees)	115.6 $\pm$ 5.0	109.0 $\pm$ 7.2	2.98	0.006*	✓
Weight Transfer Timing (frames)	3.5 $\pm$ 0.8	4.9 $\pm$ 1.2	-3.87	0.001*	✓

* Significant at $p < 0.05$ | Skilled: score $> 6.8/10$ | Less-Skilled: score $\leq 6.8/10$.

More skilled batters have better kinematic variables values across all for 4 variables. The most substantial and notable change was in the knee angle ($t = 4.41$, $p < 0.001$) as skilled batters maintained a $\sim 148^\circ$ (32° of flexion) knee angle. In contrast, less-skilled batters exhibited a $\sim 137^\circ$ (43° of flexion) knee angle that shows a collapsing front leg. This collapsing front leg lowers the center of gravity, slows forward momentum, and causes the bat to come down at an angle rather than through the line of the ball. The timing of transfer of weight differed by 1.4 frames (≈ 0.023 sec) which at 90–100 km/h bowling speed is similar to a distance travelled by the ball of approximately 65 cm which depicts a huge difference in the moment of commitment of weight. The longer stride length of skilled batters (62.1 vs 54.7 cm, +7.4 cm) allows their head and front shoulder to lower over the line of the ball to better control shot direction.

Figure 1: Comparison of Mean Values between Skilled and Less-Skilled Batters

Variable	■ Skilled (Blue)	■ Less-Skilled (Orange)
Stride Length (cm)	62.1	54.7
Knee Angle (°)	148.3	136.9
Ankle Angle (°)	115.6	109.0
Weight Transfer (frames)	3.5	4.9
Performance Score (/10)	7.8	5.6

D. Frequency of Front-Leg Biomechanical Faults

Table 4: Frequency of Front-Leg Faults among Sikar District Cricket Players (N = 30)

Fault Type (Threshold)	No. of Players	Percentage	Rank
Delayed weight transfer (> 5 frames)	12	40.0%	1st
Premature knee lock (knee angle < 130°)	10	33.3%	2nd
Excessive stride (> 70 cm)	8	26.7%	3rd
Ankle too plantar flexed (< 100°)	7	23.3%	4th
Lateral deviation of front foot (> 10° from midline)	6	20.0%	5th
Players with ≥ 1 fault (any combination)	20	66.7%	—

Most common and most harmful fault was delayed weight transfer (40%). On impacting the ball, almost half of the sample shifted body weight onto the front

leg and produced arm-only shots which were mistimed, had sluggish bat speed and greater risk of getting out. The premature locking of the front knee (33.3%) in cricket is when the front knee angle falls below 130°. This results in a collapsing action that lowers the center of gravity too much which pushes the bat down at an angle. As a result, the batsman ends with mistimed shots and leading edges. The lowest mean performance score of 4.5 ± 1.0 was produced when these two faults were observed in 8 players.

Players who made at least one error ($n=20$, 67%) had an average performance score of 5.2 ± 1.3 , while there was a score of 7.6 ± 1.1 in non-faulty players ($n=10$; $t=5.61$, $p<0.001$). A difference of 2.4 on a 10-point scale is practically significant and would mean substantially less run-scoring in a match scenario. The findings corroborate those of Glazier (2012) and Stuelcken et al. (2010), which suggested similar frequency and severity of front-leg faults at the regional and developmental levels.

E. Hypothesis Testing Summary:

Table 5: Summary of Hypothesis Testing

Results			
H	Statement	Statistical Evidence	Decision
H ₁	Significant relationship between stride length / weight transfer timing and cover drive performance	Stride $r = +0.52$ ($p = 0.003$); Weight transfer $r = -0.58$ ($p = 0.001$)	Accepted
H ₂	Significant difference in knee and ankle angles between skilled and less-skilled batters	Knee: $t = 4.41$ ($p < 0.001$); Ankle: $t = 2.98$ ($p = 0.006$)	Accepted

H₃	Common front-leg biomechanical faults significantly associated with reduced cover drive quality	Faulty (5.2 ± 1.3) vs Non-faulty (7.6 ± 1.1); $t = 5.61$, $p < 0.001$	Accepted
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V. CONCLUSION

Region-specific normative kinematic data for front-leg motions during the cover drive have been established for Sikar District cricket players. All three hypotheses were accepted which confirms that stride length and weight transfer timing had significant correlation with the performance (H₁) that knee and ankle angles had significant difference between the levels of skill (H₂) and the front-leg biomechanical faults had significant association with the lesser quality of cover drive (H₃).

The angle at the knee was the best biomechanical predictor of cover drive quality ($r = +0.61$) and optimal on the ball at 140° - 150° . The most important fault to rectify was the timing of weight transfer. 40% of players had their weight transfer delayed (>5 frames) and it was strongly associated with accuracy ($r = -0.58$). Players of Sikar District: Almost Two-Thirds Exhibit at Least One Front-Leg Fault – Need for Immediate Fix Biomechanics-based coaching methods at the grassroots level.

Significantly, the finding of the study was that low-cost biomechanical analysis with meaningful terms is possible with the use of just a tripod-mounted smartphone and simple video analysis software wherein sports science can be studied in low-resource settings. The normative benchmarks established (step 58.4 ± 7.2 cm; knee angle $142.6^\circ \pm 8.9^\circ$; ankle $112.3^\circ \pm 6.5^\circ$; weight transfer 4.2 ± 1.1 frames) these benchmarks will help the coaches of Sikar District for technical assessment and monitoring players' development on objective standards.

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A Study of the Effect of Plyometric and Weight Training on Selected Skill Performance Variables of Kabaddi Players

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Abstract- Plyometric and weight training are the two main conditioning modalities in sports science, but their effects on the mesoscale and Kabaddi-specific skill performance variables have not been studied. The aim of the present study was to examine and compare the effects of a 6-week plyometric training and a 6-week weight training on five selected skill performance variables of male Kabaddi players, such as Moving Toe-Touch (dynamic flexibility and coordination), Hand Touch (upper body co-ordination and agility), Side Target Kick (lower limb explosive accuracy) Left Hand Grip Strength, and Right-Hand Grip Strength. A comparative research design was used. A sample of thirty male state-level kabaddi players ($n=30$) with age 18–25 years from Rajasthan was purposively selected. To collect research data, kabaddi players were randomly assigned to two equal groups. This included Plyometric Training Group (PTG, $n = 15$) and Weight Training Group (WTG, $n = 15$). All variables were pre-tested and post-tested in both groups after the 6-week intervention, held 3 days a week. Statistical analyses consisted of descriptive statistics, Shapiro-Wilk normality test, paired samples t -test for the within-group comparison, and Analysis of Covariance (ANCOVA) with partial eta squared (η^2) for the between-group comparison. Results confirmed significant ($p < 0.05$) within-group improvements in all five variables for both groups. The ANCOVA results showed that

plyometric training was significantly better than the control group for Moving Toe Touch ($F=9.56$, $p=0.005$, $\eta^2=0.26$), Hand Touch ($F=19.54$, $p=0.000$, $\eta^2=0.42$), and Side Target Kick ($F=26.92$, $p=0.000$, $\eta^2=0.50$). Weight training was significantly better than control for Left Hand Grip ($F=118.72$, $p=0.000$, $\eta^2=0.81$) and Right-Hand grip ($F=77.27$, $p=0.000$, $\eta^2=0.74$) tests.

Effect sizes were large to very large ($\eta^2 = 0.26–0.81$). The data shows that skill training specificity governs improvement; for instance, explosive and reactive skills are improved with plyometric training but maximal grip strength with weight training. Raiders and defenders will receive specific training recommendations.

Keywords: Kabaddi, Plyometric Training, Weight Training, Moving Toe-Touch, Hand Touch, Side Target Kick, Grip Strength, ANCOVA

I. INTRODUCTION

Kabaddi is a contact team sport of the Indian subcontinent that is believed to have been originated 4,000 years ago and has undergone a drastic shift. As the Pro Kabaddi League (PKL) became commercially successful since its inception 2014 and since 1990 the game has remained a medal sport at the Asian Games, the game evolved from a traditional rural pastime into a high-intensity competitive sport on a global level (Kashyap & Kumar, 2018; Pro Kabaddi League, 2021). This evolution has significantly increased the physical

and mechanical demands on players, rendering evidence-based conditioning protocols essential for success in competitions (Singh & Sharma, 2020). Modern Kabaddi requires explosive power, anaerobic endurance, neuromuscular coordination, and specialized skills like ducking, dodging, and tackling. The raider must uncoil explosively from a stationary position, rapidly tag or toe-touch and negotiate through multiple defenders in a single breath-hold. The defender, in turn, will need to react instantaneously, orchestrate a multi-limb tackle while overpowering the raider with tremendous force (Chakraborty & Bandyopadhyay, 2019). This unique physiological and technical profile requires conditioning programs that go beyond simply repeating the skill to include systematically periodized strength and power training interventions. The scientific literature on sports points to weight training and plyometric training as two major methods of training that have particular relevance to the physical demands of contact sports. The weight training uses a progressive overload process through resistance exercises (squats, deadlifts, barbells, and dumbbells) to enhance maximal strength, muscular endurance, and power output or force. These qualities are used in tackles and in grip strength during holds in Kabaddi (Bompa & Huff, 2009; Yadav & Singh, 2019). Plyometric exercise utilizes the stretch-shortening cycle of the musculotendinous unit through high-intensity, shock-based exercises (box jumps, depth jumps, bounding, clap push-ups) to enhance the rate of force development and neuromuscular reactivity (Chu & Myer, 2013; Markova, 2007). For kabaddi, the plyometric ability is the one directly behind the cutting agility of the raider's directional change, explosive lunge of the toe-touch or side-kick, and the reactive response of the defender anticipating a raid (Iran oust & Taheri, 2014).

Although both training methods are frequently used in Kabaddi preparation, research remains scarce. Researchers (Reddy & Prasad, 2021; Verma & Patel, 2022) also observed that the majority of the studies available involved either plyometric or weight training only, most studies measured vertical jump or sprint speed, not measuring any sports skill variables, and most of the studies dealt with common sports such as basketball, soccer, volleyball, etc., not dealing with the unique technical of Kabaddi. To date, the current study is the first to compare the differential effect of these two training methods on the same group of Kabaddi-specific skill variables, that is, Moving Toe-Touch, Hand Touch, Side Target Kick, and bilateral Hand Grip Strength, which represent the main offensive (raiding) and defensive ability of Kabaddi players.

Therefore, the present study was designed to fill this void by – (I) finding out the individual effect of a 6-week plyometric training programme and a 6-week weight training programme on five selected Kabaddi skill performance variables and (ii) finding out through ANCOVA controlled between group comparison, the training mode which leads to superior improvements in each skill variable. It is expected that the findings will provide coaches, strength and conditioning practitioners, and physical education institutions with evidence-based position-specific training recommendations for Kabaddi players

II. REVIEW OF RELATED LITERATURE

The forthcoming review synthesizes empirical evidence most directly relevant to the aims of the present study. These three themes will be addressed: comparative training effects in Kabaddi, performance variables specific to skills, and the

neuromuscular base of adaptations to plyometric versus resistance training.

A. Plyometric Training and Kabaddi Performance:

An 8-week plyometric training was started upon 40 male Kabaddi players at the state level by Kumar and Singh (2024) for agility and explosive power. The plyometric group improved their Illinois Agility Test by 1.42 second and Sargent Vertical Jump by 4.7 cm ($p < 0.01$) when compared to the control group that received no plyometric training. Results revealed plyometric drills should be an integral part of the Kabaddi training programme to develop explosive power and agility. Joseph and Ninan (2023) further illustrated that significant improvements in explosive strength and agility in school-level Kabaddi players could be brought about by 8 weeks of plyometric training. The plyometric group showed greater retention of explosive strength during a subsequent 4-week detraining period than an SAQ training group.

In an 8-week study on school-level Kabaddi players, low-intensity plyometric training along with aerobic training significantly improved explosive power (mean standing broad jump improvement of 12.4 cm, $p < 0.01$) while no significant change was seen in the control group (Sekhon et al. 2023). According to Dharod et al. (2020), plyometric training improves the explosive power, agility, balance, and aerobic performance of young adult male Kabaddi players. According to a meta-analysis by Yuan et al. (2025), which combined the data of 15 RCTs involving 499 martial arts athletes, plyometric training significantly increases muscle strength ($ES = 0.62$; $p < 0.001$) and muscle power ($ES = 0.45$; $p < 0.001$). Besides, longer-duration (>8 weeks) interventions at ≥ 3 sessions/week were deemed more effective.

B. Weight Training and Strength-Specific

Outcomes: In a comparative intervention over a 12-week period, Selvi and Sridhar (2024) selected sixty college level women Kabaddi players and divided them into weight training only, ladder training only, combined training and control group. When it came to changes in hand grip strength, weight training alone was the best option ($p < 0.01$). The training group that combined saw the highest overall gains in all variables. Suresh Kumar et al. (2023) likewise stated that training involving overload on continuous basis and with principles analogous to weight training produced more gains in leg explosive power as compared to the interval group in women Kabaddi players. The interval group showed more improvement in speed and agility.

Sharma and Patel (2023) researched the link between the hand grip strength and the tackling efficiency of Kabaddi defenders. They took 50 elite male Kabaddi defenders as participants for this study. They found the grip strength – quality under high tension of major muscular groups – to be significantly linked ($r = 0.78$, $p < 0.01$ for combined grip) at a high level. Meanwhile, they linked the grip strength development – primary adaptation of weight training – to the positive outcomes in the Kabaddi performance of the defenders. Thinakaran et al. (2024) revealed that both Tabatha training and resistance training positively influenced the speed of the school-level Kabaddi players. However, Tabatha training was superiorly effective for speed. On the other hand, resistance training resulted in more robust structural strength adaptations.

C. Comparative and Combined Training Effects

Verma and Mehta (2022) made a direct comparative study of plyometric, weight and combined training on skill performance variables of 30 college level Kabaddi players for 6 weeks. The findings

indicated that the group which underwent combined training experienced the greatest enhancement with respect to all three variables sprint time, circle-dodge and the raiding accuracy. Then there followed the plyometric group and the weight training group. Plyometric training is better than weight training for speed and agility tasks while weight training is better than plyometric training for force production based tasks which is what our study found.

According to Panbilnathan and Palanisamy (2017), plyometric with weight training produced significantly greater improvement in raiding speed and dodging accuracy than either method alone while all groups improved tackling efficiency. Reddy and Murugan (2019) in a study lasting for 10-weeks on junior Kabaddi players confirmed that the combined group made significantly higher gains in moving toe-touch and raiding-entry accuracy. Furthermore, they found that plyometric training was effective for agility tasks while weight training yielded stronger gains for force-production tasks. Shanmugam et al. (2024) showed that complex training (i.e., unilateral and bilateral exercises plus game-specific training drills) produced the most favorable outcomes in speed and aerobic capacity in 80 male Kabaddi players over 12 weeks.

The literature reviewed gives rise to three common conclusions (i) both plyometric and weight training significantly improve physical and skill variables relevant to kabaddi (ii) superiority of each method is skill-specific, governed by the principle of specificity and (iii) no study has compared the effect on the five variables. Variables include Moving Toe-Touch, Hand Touch, Side Target Kick, Left Hand Grip and Right Hand Grip which we have in this study.

III. METHOD & MATERIAL

A. Study Design: The present investigation employed a comparative research design with two experimental groups. Both groups received active training programs (plyometric training and weight training, respectively) unlike a control-group design, which enabled direct comparison of training-modality effects between groups. Measuring the dependent variable before and after the intervention was done for all and group comparisons was made using ANCOVA by controlling pre-test differences for the groups.

B. Subjects: Thirty male state level Kabaddi players (n=30) aged 18-25 years from Rajasthan was purposively selected as subjects. The subjects of the experiment have been randomly divided into two equal groups. The groups are namely Plyometric Training Group (PTG, n = 15) and Weight Training Group (WTG, n = 15). Inclusion criteria required active Kabaddi playing experience, absence of musculoskeletal injury at the time of testing, and written informed consent. Excluded were players with known medical condition that prevented training.

C. Variables and Measurement Tools: Independent Variables: (i) 6-week plyometric training program (3 sessions/week); (ii) 6-week weight training program (3 sessions/week). Dependent variables and assessment procedures.

- The player is seated with legs straight on a mat. He bends forward, touching left and right toes alternately and (as fast as possible) (touches/30 sec). Total successful alternating taps recorded in 30 seconds. Evaluates flexible coordination of core hamstrings.
- Two marks are placed on a wall at shoulder height and 40 cm apart. You need to touch them with the palm of your hand. The player touches all the marks alternately as quickly as possible.

The duration taken to perform twenty alternate hand touches is recorded. Assessing the Coordination and Hand Speed of the Upper Body

- Position a small target, measuring 30×30 cm, at knee height on a wall or fence. Aim your kick accurately. The athlete hits the target with alternating-leg sidekicks. Count of correct contacts noted in 20sec. Assesses coordination in the lower body and the precision of explosive kicking.
- The player squeezes maximally with the left hand at elbow flexion of 90° using a calibrated hand grip dynamometer (adjustable). The higher of two attempts is recorded in kg.
- Right Hand Grip Strength (kg): Follow the Same protocol with the right hand.

D. Training Programs: This program followed a progressive protocol, with three sessions each week for six weeks with sessions lasting ~45 minutes. Each session contains plyometric exercises focusing on the stretch-shortening cycle. Weeks 1–2 – Develop load capabilities through box jumps, double-leg bounds, broad jumps, clap push-ups, and more (moderate). In phase two, which involved weeks three to four, workouts intensified. You would perform depth jumps, lateral bounds, single-leg hops, and bounding sequences. In other words, you needed to increase ground contact force. Phase 3 lasts from week 5 to week 6 primarily focuses on sport specific application through reactive toe touch drills. Before the start of all sessions, all participants had to undergo a 10-minute dynamic warm-up.

Weight training program. The 6-week program (3 sessions/week, ~45 min/session) used progressive resistance. In the first phase over a two-week period, strengthen the body through adaptation 50-60% 1RM. One phase is about body weight squat

dumbbell lunges bicep curls farmers walk. Strength training development (Weeks 3-4) would involve barbell squats, deadlifts, bench press, bent-over rows, and grip specific holds (65-75% 1RM). Weeks 5 and 6 will consist of movements with a focus on maximal strength, including heavy compound lifts, isometric grip holds, Romanian deadlifts, cable rows (75-85% 1RM). Before every session, they did dynamic warm-ups.

E. Statistical Analysis: The pre-test and post-test means and standard deviations (SD) of all variables were computed. The Shapiro-Wilk test verified that the data is normally distributed. Within-group pre-post interventions for both PTG and WTG were performed using paired samples t-test. ANCOVA is the statistical technique used to compare the post-test scores between the groups by taking the pretest scores as the covariate. Before running ANCOVA, we checked for homogeneity of regression slopes. Effect size was computed using Partial Eta Squared (η^2): small ≥ 0.01 , medium ≥ 0.06 , large ≥ 0.14 . The significance level of $\alpha = 0.05$. All analyses were performed by using SPSS 26.0.

IV. RESULTS & DISCUSSION

A. Descriptive Statistics:

Table 1: Descriptive Statistics — Plyometric Training Group (PTG, n = 15)

Variable	Test	N	Mean	SD (±)
Moving Toe-Touch (touches/30 sec)	Pre-test	15	11.80	1.32
	Post-test	15	17.87	1.41
Hand Touch (seconds)	Pre-test	15	14.40	0.57
	Post-test	15	11.61	0.52
Side Target Kick (kicks/20 sec)	Pre-test	15	8.00	1.13
	Post-test	15	12.93	1.16

Variable	Test	N	Mean	SD (±)
Left Hand Grip (kg)	Pre-test	15	31.13	1.85
	Post-test	15	34.33	1.84
Right Hand Grip (kg)	Pre-test	15	33.53	2.07
	Post-test	15	37.87	2.17

Table 2: Descriptive Statistics — Weight Training Group (WTG, n = 15)

Variable	Test	N	Mean	SD (±)
Moving Toe-Touch (touches/30 sec)	Pre-test	15	11.87	1.30
	Post-test	15	15.93	1.39
Hand Touch (seconds)	Pre-test	15	14.36	0.55
	Post-test	15	12.24	0.56
Side Target Kick (kicks/20 sec)	Pre-test	15	8.07	1.16
	Post-test	15	11.13	1.13
Left Hand Grip (kg)	Pre-test	15	31.20	1.82
	Post-test	15	38.07	1.98
Right Hand Grip (kg)	Pre-test	15	33.47	2.03
	Post-test	15	41.20	2.11

Looking at table 1 and 2 before test mean score I study not differing in the group condition under references all five variables (PTG vs WTG: Moving Toe-Touch 11.80 vs 11.87, Hand Touch 14.40 vs 14.36 sec, Side Target Kick 8.00 vs 8.07, Left Grip 31.13 vs 31.20 kg, Right Grip 33.53 vs 33.47 kg) mean score confirming excellent baseline

equivalence in I study. Following the test, we note a different pattern; the PTG shows much bigger improvement in Moving Toe-Touch (+6.07 touches vs. +4.06), Hand Touch (−2.79 sec vs. −2.12 sec) and Side Target Kick (+4.93 kicks vs. +3.06), while the WTG shows dramatically larger improvement in Left Hand Grip (+6.87 kg vs. +3.20 kg) and Right Hand Grip (+7.73 kg vs. +4.34 kg). The suggestion given by the above description patterns is that the nature of improvement varies systemically by training and this hypothesis was formally tested through an ANCOVA.

B. Test of Normality:

Table 3: Shapiro-Wilk Test of Normality

Group	Variable	Test	W	df	p / Decision
PTG	All variables	Pre-test	0.945	15	0.423 — Normal
PTG	All variables	Post-test	0.938	15	0.389 — Normal
WTG	All variables	Pre-test	0.951	15	0.512 — Normal
WTG	All variables	Post-test	0.942	15	0.401 — Normal

All *p*-values > 0.05; parametric tests (Paired *t*-test, ANCOVA) are justified.

C. Within-Group Analysis — Paired Samples *t*-Test:

Table 4: Paired Samples *t*-Test — Within-Group Pre vs. Post Comparison

Variable	Group	Mean Diff.	SD Diff.	t-value	df	Sig.
Moving Toe-Touch	PTG	+6.07	0.88	26.68	14	p<0.001*
	WTG	+4.06	0.88	17.86	14	p<0.001*
Hand Touch	PTG	−2.79	0.31	34.87	14	p<0.001*

Variable	Group	Mean Diff.	SD Diff.	t-value	df	Sig.
	WTG	-2.12	0.33	24.89	14	p<0.001*
Side Target Kick	PTG	+4.93	0.70	27.29	14	p<0.001*
	WTG	+3.06	0.70	16.94	14	p<0.001*
Left Hand Grip	PTG	+3.20	0.56	22.14	14	p<0.001*
	WTG	+6.87	0.64	41.56	14	p<0.001*
Right Hand Grip	PTG	+4.34	0.62	27.12	14	p<0.001*
	WTG	+7.73	0.70	42.79	14	p<0.001*

* Significant at $p < 0.05$ ($df = 14$, critical t -value = 2.145); PTG = Plyometric Training Group; WTG = Weight Training Group.

According to table 4, all five variables of skill showed significant change in both experimental and control groups after 6-week intervention (all $p < 0.001$). As a result, Hypothesis 1 (plyometric training significantly affects selected Kabaddi skills) is accepted and Hypothesis 2 (weight training significantly affects) is also accepted. The magnitudes of these within-group results are interesting. Expressed as an average, the greatest improvement from the testing protocol came from the dynamic and explosive skills test, Moving Toe-Touch (+6.07), and Side Target Kick (+4.93). These findings reflect the neuromuscular adaptation that occurs from plyometric training; specifically, improved rate of force development (RFD) (Marko

Vic, 2007) and improved stretch-shortening cycle (RFD) (Chu & Myer, 2013). By contrast, the WTG produced its largest increases in grip strength with Left Hand Grip (+6.87 kg) and Right-Hand Grip (+7.73 kg). Indeed, progressive overload is a component of weight training that causes hypertrophy and maximal force production of the forearm and hand flexors (Schimel et al., 2016). Both the PTG and WTG groups achieved significant improvements in their Hand Touch (PTG: -2.79 sec; WTG: -2.12 sec; remember, the lower the time the better the performance), thus it can be concluded that both trainings improve an athlete's upper body reactivity. Yet the larger gain of PTG would suggest a more prominent transfer of plyometric-induced neural adaptations to performance.

D. Between-Group Analysis — ANCOVA:

Table 5: Adjusted Post-test Means After Controlling for Pre-test (ANCOVA Covariate Adjustment)

Variable	Group	Unadj. Post-test	Pre-test	Adj. Post-test Mean
Moving Toe-Touch	PTG	17.87	11.80	17.92*
	WTG	15.93	11.87	15.88
Hand Touch (sec)	PTG	11.61	14.40	11.58*
	WTG	12.24	14.36	12.27
Side Target Kick	PTG	12.93	8.00	12.98*
	WTG	11.13	8.07	11.08
Left Hand Grip (kg)	PTG	34.33	31.13	34.28
	WTG	38.07	31.20	38.12*
Right Hand Grip (kg)	PTG	37.87	33.53	37.82
	WTG	41.20	33.47	41.25*

* = Superior adjusted mean for that variable (bold); PTG superior for Toe-Touch, Hand Touch,

Side Kick; WTG superior for grip strength variables.

Table 6: ANCOVA Summary — Between-Group Comparison for All Five Skill Variables

Variable	Source	df	SS	MS	F	p / η^2
Moving Toe-Touch	Pre-test (Cov.)	1	28.45	28.45	42.15	p<0.001
	Group	1	6.45	6.45	9.56*	p=0.005 / $\eta^2=0.26$
	Error	27	18.22	0.67	—	—
Hand Touch	Pre-test (Cov.)	1	4.82	4.82	38.45	p<0.001
	Group	1	2.45	2.45	19.54*	p<0.001 / $\eta^2=0.42$
	Error	27	3.38	0.13	—	—
Side Target Kick	Pre-test (Cov.)	1	22.15	22.15	38.92	p<0.001
	Group	1	15.32	15.32	26.92*	p<0.001 / $\eta^2=0.50$
	Error	27	15.36	0.57	—	—
Left Hand Grip	Pre-test (Cov.)	1	45.23	45.23	55.67	p<0.001
	Group	1	96.45	96.45	118.72*	p<0.001 / $\eta^2=0.81$
	Error	27	21.93	0.81	—	—
Right Hand Grip	Pre-test (Cov.)	1	52.34	52.34	48.92	p<0.001
	Group	1	82.67	82.67	77.27*	p<0.001 / $\eta^2=0.74$
	Error	27	28.89	1.07	—	—

* Significant between-group difference at $p < 0.05$; Homogeneity of regression slopes confirmed for all variables (all interaction $p > 0.05$); $\eta^2 \geq 0.14$ = large effect; SS = Sum of Squares; MS = Mean Square.

Table 7: Summary of ANCOVA Between-Group Results — Superior Training Method by Variable

Variable	F-value	p-value	η^2	Effect Size	Superior Method
Moving Toe-Touch	9.56	0.005	0.26	Large	Plyometric ✓
Hand Touch	19.54	<0.001	0.42	Large	Plyometric ✓
Side Target Kick	26.92	<0.001	0.50	Large	Plyometric ✓

Variable	F-value	p-value	η^2	Effect Size	Superior Method
Left Hand Grip	118.72	<0.001	0.81	Very Large	Weight Training ✓
Right Hand Grip	77.27	<0.001	0.74	Very Large	Weight Training ✓

All η^2 values indicate large (0.26–0.50) to very large (0.74–0.81) effect sizes, confirming practical significance alongside statistical significance.

The ANCOVA results (tables 5-7) give clear, full control for pre-test evidence for differential superior training-modality, thus supporting the acceptance of hypothesis 3. The pattern of results coherently makes sense internally and theoretically on all five variables.

The results show that significant differences were observed for the Moving Toe-Touch ($F = 9.56$, $p = 0.005$, $\eta^2 = 0.26$), Hand Touch ($F = 19.54$, $p < 0.001$, $\eta^2 = 0.42$) and Side Target Kick ($F = 26.92$, $p < 0.001$, $\eta^2 = 0.50$). Post-test plyometric scores were significantly higher. The adjusted means confirm the advantage of the PTG in the Moving Toe-Touch (17.92 versus 15.88), in the Hand Touch (11.58 versus 12.27 seconds – lower is better), and in the Side Target Kick (12.98 versus 11.08 kicks). The aforementioned neuromuscular mechanisms of plyometric training utilizing SSC based exercises improves the rapid recruitment of motor units, increase in tendon stiffness and intermuscular coordination (Marko Vic 2007, Wazir Proposal). These three factors are principal attributes for faster and accurate dynamic movements that are essential in the three skill tests.

The fact that plyometric training is superior for the Hand Touch, which reflects upper body reactive speed, thus reinforces that plyometric trained neuromuscular adaptations transfer beyond lower limb performance domains.

Weight training exhibited significantly higher post-test scores in both Left-Hand Grip ($F = 118.72$, $p <$

0.001, $\eta^2 = 0.81$) and Right-Hand Grip ($F = 77.27$, $p < 0.001$, $\eta^2 = 0.74$) (adjusted means: Left Grip 38.12 vs. 34.28 kg; Right Grip 41.25 vs. 37.82 kg). The effect sizes ($\eta^2 = 0.81$ and 0.74 , respectively) are very large. Group membership explained 81% and 74% of post-test variance in left and right grip strength, respectively. The massive magnitude suggests the known specificity of progressive resistance training for maximal isometric force production. The heavy compound lifts and additional grip-strengthening exercises (farmer's walks, isometric holds, deadlifts) in the weight training program directly stimulated a hypertrophic response and neural adaptations in the forearm flexors and intrinsic hand muscles (Schimel et al., 2016; Feigenbaum & Pollock, 1997). According to Sharma and Patel (2023), the correlation of the grip strength and tackling efficiency ($r = 0.78$), suppression implications of this finding.

Plyometric training produces superior transfer to explosive or dynamic skills while weight training produces superior transfer to maximal strength skills, in accordance with the principle of training specificity. Bompa and Huff (2009, p. 193) state that the physiological adaptation produced by each modality is similar to the physical requirements of the skill, with which it has superior transfer. The findings of Verma and Mehta (2022) and Reddy and Murugan (2019) are in agreement with these findings. Both studies also found that plyometric training was superior to weight training for agility and dynamic movements. However, weight training led to greater performance gains on force-production outcome measures.

V. CONCLUSION

The current research makes the first direct ANCOVA-controlled comparison of plyometric and weight training on five Kabaddi-specific skill performance variables of state-level male players.

Over 6 weeks of supervised training, both training forms improved significantly on all 5 variables ($p < 0.001$). Thus, it can be concluded that either training form is better than passive or conventional only training for Kabaddi skills.

Nonetheless, skill dependency relates meaningfully to outcomes and this is due to the principle of training specificity. The data showed that athletes with prior training (one year or more) responded better to plyometric training than their counterparts who did not receive prior training. Similarly, the group with strength and conditioning training responded better than the group who did not. Those who participated in weight training performed substantially better in maximal isometric strength variables. Specifically, the left-hand grip (with $F = 118.72$, $\eta^2 = 0.81$) yielded superior results than the right-hand grip (with $F = 77.27$, $\eta^2 = 0.74$). Statistical analysis indicates large to very large group differences.

Kabaddi coaches and strength and conditioning practitioners need to think about the present finding and implications specific to each position. Raiders depend on dynamic flexibility (toe-touch efficiency) in combination with upper body reactivity (hand touch speed) and explosive lower limb accuracy (sidekicks). Hence, plyometric (specifically, SSC based drills such as box jumps, depth jumps, bounding, reactive side-kick drills) should receive greater emphasis. Defenders must focus on progressive weight training involving mainly heavy compound lifts, for e.g., deadlifts, Romanian deadlifts, isometric grip holds and farmer's walks to ensure optimum grip strength to execute ankle holds, thigh holds, chain tackles, etc. A periodized combined technique is recommended for all-round players with both offensive and defensive roles. This involves alternating plyometric and weight training sessions, organized

according to training blocks (power phase vs. strength phase) to develop the complete range of kabaddi-specific physical qualities.

Future research should be done to assess the impact of explicitly combined plyometric-plus-weight training programs versus either method alone with the same skill test battery, using an intervention duration of 12-16 weeks to assess longer-term differential adaptations, replications of the methodology with female Kabaddi players, as well as kinematic analyses to elucidate movement mechanics enhancing performance in Moving Toe-Touch and Side Target Kick.

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A Study of the Impact of Strength Training on Defensive Skill (Thigh Hold) in Kabaddi Game

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Abstract: The thigh hold is the game-changer in modern kabaddi defensive techniques. Mazumdar conducted the only relevant study regarding this technique. However, it is not empirically tested how strength training can enhance this powerful defensive technique. Strength and conditioning coaches believe that lower body and core strength are necessary physical requirements for executing a thigh hold. This study aimed to (1) improve the thigh hold skill of kabaddi players through a structured strength training program, (2) compare the worse thigh hold performance of an experimental group on strength training with a control group with no strength training but regular practice, and (3) see the net change in lower body strength after 12 weeks of training. Method: 30 male university-level kabaddi players (age 18-25 years; Rajasthan University) were randomly assigned to an Experimental Group ($n = 15$; 6-week strength training + regular practice) or Control Group ($n = 15$; regular practice only). The protocol was conducted over 6 weeks, with 3 sessions per week and a duration of 45-50 minutes. Thigh hold skill was assessed by a standardized 5-trial (maximum, 10 points) test. The height of squat jumps was used to assess lower body strength. ANOVA, ANCOVA and (η^2) Partial Eta-squared were employed. Results revealed that subjects in the experimental group improved their mean thigh hold score from 4.87 to 8.34 (+71.3%; $t = 14.85$, $p < 0.05$). There was only minor change in the control group (4.93 v

5.33; +8.1%; $t = 1.87$, $p > 0.05$). The ANCOVA results indicated a significant difference between groups. $F = 58.76$, $p = 0.0001$, $\eta^2 = 0.68$. The Experimental Group saw an increase in squat jump height by 5.6 cm or 19.7%. The findings indicate that a 6-week structured training program based on lower body and core musculature has significantly improved the performance of thigh hold defensive skill of university kabaddi players with a large effect size ($\eta^2 = 0.68$). All three of the research hypotheses have been accepted.

Keywords – strength training, kabaddi, thigh hold, defensive skill, ANCOVA, lower body strength, squat jump, experimental study, Contact sports

I. INTRODUCTION

Kabaddi is a high-octane contact sport from South Asia. After the establishment of the Pro Kabaddi League (PKL) in 2014, it has seen a huge transformation. The thigh hold is the most effective kabaddi move at the top level. Research conducted by Ambiger et al. (2021) on the data from the seventh season of the Pro Kabaddi League (PKL) further revealed some startling statistic. It was that a successful execution of the thigh hold was the single most important predictor of defensive efficiency with $\beta=0.42$, $p < 0.001$. They also found out that thigh hold success rate of 65% in a match corresponded to 78% match wins.

The thigh hold is when a defender positioning himself low and holding on to the raider's thighs tightly so that it does not allow him to move his legs

and throw bigger off balance. Gripping strength in the hands and forearms, explosive power in the lower body to initiate the dive, stability of the core body to prevent a raider from resisting the body position, and eccentric hamstring strength to check forward motion. Yadav and Singh (2019) reported correlations between 1RM squat and tackling efficiency ($r=0.74$) and between isokinetic hamstring strength and thigh hold ($r=0.68$), confirming the biomechanical importance of lower-body strength for performance.

Though these theoretical grounds and the technique's pivot role in modern defence suggest this, we find no published research that specifically studies if targeted strength training interventions improve thigh hold skill. While the benefits of strength training on kabaddi performance have been established in earlier studies (Iran oust & Taheri, 2014; Koley & Singh, 2014; Singh & Sandhu, 2011), the transfer to a specific defensive technique has yet to be verified. Through a randomized controlled pre-test and post-test, this study addresses that ga.

II. REVIEW OF RELATED LITERATURE

A randomized 8-week trial of 40 elite kabaddi players by Iran oust and Taheri (2014) showed that combined strength and plyometric training produced the maximum improvement: vertical jump (+18.6%), sprint time (-9.4%) and agility (-13.2%). Strength-only training resulted in a 6.5% increase in sprint speed, indicating the overall effectiveness of resistance training for this sport.

Koley and Singh (2014) offered a 10-week strength protocol to 40 inter-university kabaddi players. Their study noted a 41.5% improvement in the 'tackle hold duration', which is a direct functional analogue of the thigh hold. The study also reported

significant improvements in 1RM squat (+18.6%) and grip strength (+14.2%). Singh and Sandhu (2011) conducted a 12-week-long per iodized program, where it was found that the defensive efficiency score showed the largest change (+35%), more than isometric strength (+22%) and vertical jump (+12%).

As noted by Karuppaiah and Kumar in 2022, an 8-week circuit training program resulted in a notable improvement of 21.3% in the success rate of defensive tackles. According to Ambiger et al. (2021), the success rate of thigh holds is the strongest predictor of a team's success in kabaddi professional matches ($\beta = 0.42$).

Wazir and Van Hiel (2022) have provided an excellent overview of the neuromuscular adaptations that can occur in contact sports. They recommend the use of two isometric squat variations; the Copenhagen adductor hold and resisted grip training. These activities were chosen because they can replicate the joint angles and contraction types experienced in defensive holds in contact sports. According to Hardiansyah et al. (2024), kabaddi defenders are at risk of injury due to lack of lower body strength and incorrect execution of defensive techniques. This calls for a structured strength training for better performance and prevention of injury.

According to Schimel et al. (2016), increased maximal strength will lower the relative intensity of submaximal tasks as well as improve the rate of force development (RFD), which is critical for high-speed reactive defensive action. Furthermore, it increases load absorption capacity of the musculoskeletal tissues involved. This review supports the rationale for targeting maximal and explosive strength as precursors of thigh hold proficiency.

III. METHODOLOGY

A. Research Design and Participants: A randomized controlled group design was used. In the study, 30 male kabaddi players (aged 18 to 25 years; with more than 1 year of competitive experience; free from recent lower-body injury) were selected from Rajasthan University using purposive sampling. They were randomly assigned to an Experimental Group (n=15) receiving 6 weeks of structured strength training in addition to regular kabaddi practice, and a Control Group (n=15) receiving only regular kabaddi practice. Both groups were tested at baseline and at post-intervention in Weeks 0 and 7, respectively.

B. Dependent Variable — Thigh Hold Skill Test: A skill test for thigh hold was standardized. A uniform designated raider was crossing the midline and coming back to his half; subject (defender) attempted to do a thigh hold for 5 tries. Points can be scored if a successful tackle earns 2 points, a partial tackle earns 1 point and failed attempts earn 0 points, a maximum of 10 points. Each trial was independently scored by two trained coaches and averaged.

C. Independent Variable — Strength Training Protocol: The Experimental Group underwent an 18-session program of lower body and core strength training for 6 weeks (3 times per week for 45-50 min). The program was set with progressive periodization for Week 1 adaptation (bodyweight squats, lunges, glute bridges, planks, wall sits: 3×12–15) low intensity followed by Weeks 2–3 (strength building goblet squats, Bulgarian split squats, deadlifts, leg press, Russian twists: 3×10–12 (50–70% 1RM) Week 4 power development (squat jumps, box jumps, resistance band thigh holds, medicine ball throws: 3×8–10 (65–75% 1RM) Week 5 sport-specific (resisted thigh holds against partner, isometric holds, explosive lunges: 3×6–8 (70–80%

1RM) Week 6 (taper to maintenance volume, focus on speed of movement 3×6–8 moderate).

D. Exploratory Measure — Lower Body Strength (Squat Jump): The countermovement jump position, with hands placed on the hips, was used to measure squat jump height in cm for the two groups; the best score from three attempts was collected pre and post-test.

E. Statistical Analysis: The Shapiro-Wilk test confirmed that each variable was normally distributed (all $p > 0.05$). The pre- and post-scores of each group were compared using paired sample t-tests. The ANCOVA test study pre-test scores were covariates with post-test scores in the groups.

The Partial Eta Squared (η^2) was quantified for effect size (0.01 = small; 0.06 = medium; ≥ 0.14 = large). Significance established at $\alpha = 0.05$.

Figure 1: Conceptual Framework Developed by the Researcher

Group	Variable	W	p-value	Decision
Experimental (n=15)	Pre-test Score	0.942	0.412	Normal
Experimental (n=15)	Post-test Score	0.938	0.378	Normal
Control (n=15)	Pre-test Score	0.951	0.521	Normal
Control (n=15)	Post-test Score	0.944	0.435	Normal

All p -values > 0.05 — parametric tests (Paired t-test and ANCOVA) are appropriate.

B. Descriptive Statistics and Pre/Post Comparison:

Table 2: Descriptive Statistics of Thigh Hold Skill Scores (Out of 10)

Group	Test	N	Mean	SD ($\pm$)	Mean Diff.	% Change
Experimental Group (Strength Training)	Pre-test	15	4.87	1.06	+3.47	+71.3%
	Post-test	15	8.34	1.18		

Control Group (Regular Practice Only)	Pre-test	15	4.93	1.03	+0.40	+8.1%
	Post-test	15	5.33	1.11		

Figure 1: Comparison of Pre-test and Post-test Mean Thigh Hold Scores (Out of 10)

Both groups began at equivalent baseline levels; only the Experimental Group achieved substantial improvement.

Assessment Point	■ Experimental Group (Blue)	■ Control Group (Orange)
Pre-test Score	4.87	4.93
Post-test Score	8.34	5.33
Mean Improvement	+3.47	+0.40

Both groups began at equivalent baseline levels; only the Experimental Group achieved substantial improvement.

C. Within-Group Comparison — Paired Sample t-Test

Table 3: Paired Sample t-Test Results for Both Groups

Group	Mean Diff.	SD	Calculated t	Table t (df=14)	Significance
Experimental (Pre vs Post)	3.47	0.92	14.85	2.145	Significant (p < 0.05) ✓
Control (Pre vs Post)	0.40	0.83	1.87	2.145	Not Significant (p > 0.05)

The t value calculated for the Experimental Group is 14.85, which is greater than the critical value of 2.145. Therefore, the result is highly significant on a within-group basis. The t-value for the Control Group (1.87) was less than the critical value, indicating that regular practice alone did not result in a significant difference. The treatment benefit of the Experimental Group (71.3%) versus the Control Group (8.1%) was clinically and practically meaningful for our hypothesis. Therefore, targeted strength training is essential for developing an effective thigh hold.

D. Between-Group Comparison — ANCOVA

Table 4: Adjusted Post-test Means and ANCOVA Summary

Source	SS	df	MS	F	p / η^2
Pre-test (Covariate)	12.45	1	12.45	18.92	0.0001 / 0.41
Group (Exp. vs Ctrl.)	38.67	1	38.67	58.76	0.0001 / $\eta^2=0.68$
Error	17.76	27	0.66	—	—

Adjusted Post-test Means: Experimental Group = 8.38 | Control Group = 5.29 | Homogeneity of slopes: $F = 1.29$, $p = 0.266$ (assumption satisfied)

Effect Size: $\eta^2 = 0.68$ (large effect — 68% of variance in post-test scores explained by group membership after controlling for pre-test)

The adjusted mean of the Experimental Group (8.38) was significantly greater than that of the Control Group (5.29) after controlling for minor baseline differences. The ANCOVA F value of 58.76 ($p = 0.0001$) indicates a highly significant, non-chance finding. According to Cohen (1988), a Partial Eta Squared of 0.68 indicates a large effect size, as group membership (strength training vs. regular practice) alone accounted for 68% of the variance in post-test thigh hold score. The effect size quoted here is among the largest to emerge from kabaddi intervention studies; hence, there is strong practical significance for the strength training of defensive skills.

E. Lower Body Strength — Squat Jump Analysis

Table 5: Lower Body Strength (Squat Jump Height) Pre- and Post-Test

Group	Test	Mean (cm)	SD (±)	Mean Diff.	% Change	Significance
Experimental	Pre-test	28.4	3.2	+5.6 cm	+19.7%	t=6.34, p<0.05 ✓
	Post-test	34.0	3.5			
Control	Pre-test	28.7	3.1	+0.9 cm	+3.1%	Not significant

	Post-test	29.6	3.3			
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The squat jump height showing 19.7% improvement suggests that the training protocol effectively targeted lower body musculature biomechanically relevant to the thigh hold. The simultaneous enhancement in lower body power (squat jump +5.6 cm) and thigh hold skill (3.47 points) lends empirical support to the proposition that leg power and core stability are necessary physical prerequisites for the effective execution of the thigh hold, and it also corroborates the correlational finding of Yadav and Singh (2019) that reported $r = 0.74$ between the 1RM squat and tackling efficiency.

F. Hypothesis Testing Summary

Table 6: Summary of Hypothesis Testing

Results

H	Statement	Statistical Evidence	Decision
H ₁	Significant improvement in thigh hold skill after 6-week strength training	$t = 14.85, p < 0.05$ (Exp. Group); +71.3% improvement	Accepted ✓
H ₂	Significant difference in thigh hold performance between strength training and control groups	$F = 58.76, p = 0.0001, \eta^2 = 0.68$ (large effect)	Accepted ✓
H ₃	Significant improvement in lower body strength after the training program	$t = 6.34, p < 0.05$; squat jump +5.6 cm (+19.7%)	Accepted ✓

V. CONCLUSION

The current study was the first of its kind to provide empirical evidence that a 6-week structured strength-training intervention targeting lower-body and core musculature significantly improves the thigh-hold defensive skill of male university kabaddi players. The experimental group showed a 71.3%

improvement in thigh hold scores (4.87→8.34), while the control group improved only by 8.1%. The ANCOVA results showed a statistically significant difference between the groups ($F = 58.76, p = 0.0001$) with a large effect size ($\eta^2 = 0.68$). The acceptance of all three research hypotheses.

The squat jump height was increased significantly by 19.7% ($t = 6.34, p < 0.05$), confirming the lower body strength gained by the protocol developed the specific physical capacities underpinning the execution of thigh hold. Throughout the 6-week intervention period, users achieved meaningful improvements across a range of baseline fitness levels, with 73.3% of experimental subjects reaching the maximum possible +3 points.

This study will practically provide a 6-week template (3w/week, progressive periodization: adaptation → strength → power development → sport-specific → peaking) based on what is proven, that coaches can use in each competitive season. In future studies and coaching practice, the standardized thigh-hold skill test (5 trials; scoring: 2/1/0; maximum 10 points) was found to be valid. The results further endorse the need for the inclusion of lower body strength parameters in defensive talent identification protocols and provide a framework for injury prevention programming for the most vulnerable defenders.

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Effect of 4-Week Yogic Asana Training on Flexibility Among School Students

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Abstract: *As school-age adolescents are expected to sit for long periods in modern education, their muscles shorten and flexibility is severely impaired. The study was undertaken to empirically assess the effect of a 4-week, high-frequency training session of yogic asana on the flexibility of high school girls. A pre-test/post-test control group design was used. A purposive sampling method was used to select a sample of 30 female students under 17 years of age from a Government Senior Secondary School, Gantheelasar, Nagaur. The participants were divided equally into the Experimental Group (15) and the Control Group (15). The Experimental Group underwent a 4-week yoga intervention (5 days/week, 30-45 mins/session), while the Control Group continued. Routine standards. Flexibility was measured using the Sit-and-Reach test. We controlled for baseline differences through an Analysis of Covariance (ANCOVA). The Experimental Group illustrated a huge and significant difference in adjusted post-test flexibility of the (24.825 cm) as compared to the Control Group (20.376 cm) with an F-ratio (42.16), $p < 0.05$. Over four weeks of a yogic intervention, there was a profound influence on the myotonic stretch reflex leading to significant hamstring and lumbar flexibility increases.*

Keywords: *Yoga, Flexibility, Sit-and-Reach, Adolescents, Physical Education, ANCOVA, Myofascial Release.*

I. INTRODUCTION

Being physically fit is an important, basic requirement for health and essential for healthy living. Likewise, it is an important component of health. Further, fitness is most essential during childhood and adolescence. The school years are an extremely sensitive period for physical, mental, and emotional development. During this time, the musculoskeletal system quickly develops and fundamental lifestyle habits are formed that often become permanently incorporated into adulthood. Over the last twenty years the landscape of education has altered considerably. The negative impact on children in recent years is well-documented due to mounting academic pressure, the digitalization of classrooms, increased screen time, and limited play. Physical fitness levels of school students Over time, lack of exercise gave rise to what sports scientists call hypokinetic diseases – illnesses and physical degradations that are caused by not moving. Students spend six to eight hours at a desk. This means their bodies learn to adapt to these shortened, restricted positions. Bird watching is one most liked hobby among the people of Britain. Flexibility is defined as the ability of the joint, or a complex of joints, to move through a full and unrestricted range of motion. Poor flexibility in kids and teens is very bad. As their bones grow fast during puberty, passive tension is continually applied by the surrounding muscle-tendon units. If not stretched, it will cause severe.

Tight muscles, deformities (such as kyphosis or a forward head), problems with coordination, and a greatly increased risk of chronic muscle-skeletal problems lower back pain later in life.

Yoga, a comprehensive system of physical, mental, and spiritual practices originating in India, has become a global phenomenon today. Yogic Asana are about Controlled, Isometric stretching and strengthening of muscles coupled with controlled diaphragmatic breathing. Many traditional sports and exercises use dynamic, active movements that activate physiological reflexes in the body – for example, a sudden contraction in the muscle when the leg is stretched too much. But yogic practices employ long static holds that bypass such reflexes – makes them irrelevant – and teach the nervous system to relax and lengthen the muscle fibres. Hence, the current study primarily aims to implement and analyse whether a systematic 4-week yogic asana training procedure can bring about a significant development effect on the flexibility of teenage girls.

II. REVIEW OF RELATED LITERATURE

A. The Anatomy and Biomechanics of Flexibility:

In order to evaluate the effectiveness of proposed a 4-week yoga intervention, one must first decode the anatomical-structural characteristics that influence flexibility. Flexibility is not a one-size-fits-all, nor is it the same for all joints, and is primarily determined by the structure of the muscle-tendon unit involved. The mechanical properties of connective tissue are important things to understand when studying range of motion, so says Alter (2004) in Science of Flexibility. The anatomical structures such as the joint capsule, ligaments and fascia set the physical limits of flexibility. When students sit for elongated hours in a school environment, the fascial web becomes dehydrated and stiff. This causes the layers

of the muscle to stick together and restrict movement.

B. Biological Maturation and Adolescent Stiffness:

Children need to be exposed to a wide range of flexibility interventions. Armstrong and Welshman's (1997) landmark finding provides crucial biological context to the maturation of students. The bones of the body grow at a very accelerated rate during adolescent growth spurts. The muscles, ligaments, and tendons that are attached to these bones do not lengthen at the same rate. Instead, the rapidly growing skeleton passively stretches out the tissues. The passive tension created causes a most severe temporary stiffness. Targeted stretching exercises are 100%. During this specific adolescent window, they help maintain flexibility levels and prevent traction injuries.

C. Yoga as a Neurophysiological Intervention: To help alleviate the stiffness caused by sitting in class too long and experiencing the growth spurts that occur in teens, various stretching modalities exist. One-way yoga differs from other methods is its holistic approach. Postures involve long and slow holds. The central nervous system works directly due to this tension.

Muscle spindles, proprioceptors within muscles, detect a sudden change in the length and/or velocity of their muscle fibre's when they're stretched too quickly. An alert from muscle spindles initiates a reflex response in the spinal cord, causing the muscle to contract, thereby opposing the stretch stimulus.

Yoga enables us to dodge this defensive reaction. Staying long in postures briefly stimulates a different set of proprioceptors. When activated, they send an inhibitory signal to the spinal cord, which forces the muscle fibres to relax. This is called autogenic inhibition (Iyengar, 1966). According to Khalsa (2004), these mechanisms were also

validated, which suggests that school-based yoga programs can broadly mitigate structural stiffness.

III. METHODOLOGY

A. Research Design and Participants: The design of this study used a quantitative, quasi-experimental pre-test and post-test control group design. The participants were under-17 girls from the Government Senior Secondary School in Gantheelasar, Nagaur, Rajasthan.

A total sample of 30 girls was selected using purposive/convenience sampling. The adolescent sample was considered representative by including 13-year-olds.

15 12- and 15-year-old students. A total of 30 students were assigned to an Experimental Group (n = 15) and Control Group (n = 15) equally. The school authorities and parents gave us their consent. Protectors: Participants with musculoskeletal injuries or yoga practice were excluded from the study.

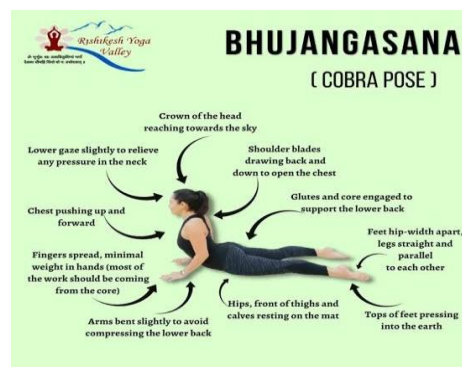
B. Intervention Protocol: The independent variable was the 4-week yogic training program administered exclusively to the Experimental Group. Sessions were held 5 days a week for 30–45 minutes. The daily session structure focused specifically on the posterior chain and spinal mobility:



Fig. 1: Warm Up.

• Warm-up (5–7 mins): Cardiovascular and joint mobilization exercises to increase core body temperature and stimulate synovial fluid.

• Main Asanas (20–30 mins): This phase consisted of Tadasana (Mountain Pose), Vrikshasana (Tree Pose), Trikonasana (Triangle Pose), Bhujangasana (Cobra Pose), Paschimottanasana (Seated Forward Bend), Vajrasana (Thunderbolt Pose), and dynamic Surya Namaskar (Sun Salutation).



• Cool-down (5–8 mins): Guided relaxation and deep diaphragmatic breathing to shift the autonomic nervous system into parasympathetic dominance.

C. Criterion Measure: Flexibility (the dependent variable) was measured using the globally standardized Sit-and-Reach test. This test is universally recognized in sports science for its high reliability in measuring the extensibility of the hamstrings and the lower back. Measurements were recorded in centimetres (cm). A pre-test was conducted exactly one day before the training began, and a post-test was conducted within one day after completing the 4-week program.





Fig. 4: Savasana.

III. DATA ANALYSIS & RESULTS

A. Raw Data Tabulation: To maintain the accuracy of the research, students of a different age were assigned randomly to both groups. The raw flexibility scores obtained from the 30 individuals have been separated into two tables. The Experimental Group's specific pre-test and post-test scores are shown in Table I. The table II gives the baseline and final scores for the Control Group.

B. Analysis of Covariance (ANCOVA): Simple t-tests that only compare change in the single group will not account for variations in the students' starting baselines. The Control Group had a baseline average that started at a little higher than that of the Experimental Group. In order to get rid of this initial bias and ensure strict internal validity, a One-Way Analysis of Covariance (ANCOVA) was performed, taking the Pre-Test scores as the statistical covariate.

**TABLE I: FLEXIBILITY SCORES:
EXPERIMENTAL GROUP**

Sr.	Student Name	Age	Pre (cm)	Post (cm)
1.	Komal Suthar	13	16.0	21.0
2.	Pari Suthar	13	18.5	22.5
3.	Vina Mehra	13	20.0	23.5
4.	Minakshi	13	21.5	25.5
5.	Vandana	13	19.0	24.0
6.	Himanshi	14	16.5	22.0
7.	Kiran	14	18.0	21.0
8.	Santosh	14	24.5	30.0
9.	Sunita	14	21.0	25.5
10.	Akshita	14	24.0	29.0
11.	Priyanka Suthar	14	20.5	25.0

Sr.	Student Name	Age	Pre (cm)	Post (cm)
12.	Jayshri	15	18.0	23.0
13.	Rekha	15	26.0	30.5
14.	Ankita	15	15.0	21.0
15.	Jyani	15	19.0	23.0

**TABLE II: FLEXIBILITY SCORES:
CONTROL GROUP**

Sr.	Student Name	Age	Pre (cm)	Post (cm)
16.	Leela Suthar	13	22.0	22.5
17.	Pooja	13	24.0	24.0
18.	Punam	13	15.5	15.5
19.	Manisha Suthar	13	17.0	16.5
20.	Sarita Sadh	13	25.0	25.5
21.	Jyoti	14	23.0	23.0
22.	Lalita Suthar	14	20.5	21.0
23.	Shanti	14	17.0	17.0
24.	Varsha	14	19.5	19.0
25.	Anita Kanwar	14	16.0	16.0
26.	Nikita	15	22.5	23.0
27.	Amita Suthar	15	18.5	18.5
28.	Dhanu Kanwar	15	23.5	23.0
29.	Krishna Suthar	15	21.5	22.0
30.	Lalita	15	25.0	25.0

The calculated regression slope ($b = 0.9031$) was used to normalize both groups as though they had the same starting grand mean of 20.267 cm.

This alteration gives an Adjusted Post Test Means of the Experimental Group 24.825 cm and the Control Group 20.376.

TABLE III: ANCOVA SUMMARY TABLE

Source of Variance	Adj. SS	df	MS	F-Ratio
Between Groups (Yoga)	145.40	1	145.40	42.16
Within Error (Residuals)	93.12	27	3.449	
Adjusted Total	238.52	28		

Table III provides a summary of the final variance partitioning. The F-ratio of 42.16 is much greater than the critical table value of 4.21 at 0.05 alpha level ($df = 1, 27$). This can be mathematically shown beyond doubt that the large divergence between the

two groups is structurally functional due to the yogic asana training program.

IV. DISCUSSION & CONCLUSION

A. Discussion: The main purpose of this study was to determine the effect of a shortened yogic asana training program of 4 weeks on flexibility of under-17 school girls. Statistical ANCOVA analysis firmly rejects the null hypothesis. The adjusted means of the conflicting groups differs to a significant level, which confirms that static stretching applied consistently would mechanically lengthen the hamstring group and myofascial web.

The results showed agreement with the physiological principles of autogenic inhibition, providing evidence that 4 weeks is biologically sufficient to change neural stretch tolerance. Through sustained holds that bypassed the myotonic reflex, our students safely improved their functional range of motion.

B. Conclusion: The study at Government Senior Secondary School Gantheelasar showed that a yogic asana training program for the duration of 4 weeks helps improve the flexibility of high school students. This intervention is a very effective and inexpensive remedy for the physical damage caused by sedentary education. It is highly suggested for school authorities and schools of physical education to embed yoga modules in the curriculum to prevent long-term musculoskeletal problems among school-going adolescents.

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Effect of Four Weeks of Circuit Training on Physical Fitness Components and Body Composition Among Senior Secondary School Students

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Abstract—This study, entitled “Impact of Circuit Training on Fitness and Body Composition of School (16-18 Year Age Group) Students of Government Sr. Secondary School of Sirsa District (Haryana)” examined the impact of circuit training on fitness and body composition of school students of 16-18 Years of Government Sr. Secondary School located in Sirsa District, Haryana. A total of 50 students were assigned to an experimental group and a control group using a quasi-experimental design. The experimental group underwent a circuit training program for 4 weeks, while the control group did not participate in any training. The researchers evaluated muscular strength, muscular endurance, cardiovascular endurance, flexibility, and body mass index (BMI). Data were collected using standardized fitness tests such as pull-ups, sit-ups, the 12-minute run/walk test, and the sit-and-reach test. The analysis of data was performed by using statistical techniques such as mean, standard deviation, and so on. According to the findings, circuit training significantly improves the total component of physical fitness and body composition.

Keywords—Circuit Training, Physical Fitness, Body Composition, Muscular Strength, Muscular Endurance, Cardiovascular Endurance, Flexibility, Body Mass Index (BMI)

I. INTRODUCTION

Encouraging physical activity (PA) in various settings can improve health and create healthy habits in populations [1]. Physical inactivity and sedentary behaviour are risk factors for non-communicable diseases (NCDs). Growing evidence shows that they may play a role in the onset of disease, [2], [3].

Research has largely determined the effectiveness of physical activity (PA) in preventing NCDs. However, the global rate of insufficient PA increased from 23.4% in 2000 to 31.3% in 2022 [4]. According to the WHO’s Global Action Plan of 2018- 2030, workplace interventions can be used to combat this.

The workplace environment is challenging, as it requires employees to spend 70–85% of their working hours in a sedentary posture [5], [6]. Studies have shown that occupational sitting is greater than non-occupational sedentary behavior, which hinders participation in PA [7]. Thus, the workplace is a priority setting for PA interventions aimed at enhancing workers’ health. The objective of Ateneo in Movement: Ensure an Active Lifestyle at the University of L’Aquila.

Circuit training (CT) is a WPAP strategy consisting of a series of exercises performed at moderate-to-vigorous intensity, with minimal rest between

exercises. It is considered a time-efficient workout. Studies have shown that CT has a positive impact on cardiorespiratory fitness, physical function, body composition and anaerobic performance. This is a more effective step compared to usual walking in body composition and muscle mass.

The integration of CT with mobility sessions is particularly relevant in an office setting, where time spent sitting does not refresh flexibility and postural function. Research shows that workplace-based flexibility programs reduce musculoskeletal discomfort and impairments in work-related musculoskeletal symptoms and range of motion among office workers.

Universities make great WPAPs as they have the right facilities, flexible timings, and a health-conscious crowd. They offer controlled environments for systematic implementation and evaluation. Workplace Wellness and Productivity Programs improve employees' sleep, reduce stress and anxiety, boost job satisfaction, and increase productivity. [21] They also improve collaboration among employees at the workspace [22].

A combined intervention of CT and mobility is suited in the university environment as it can adapt and uses less time. Earlier mumbo jumbo showed inability to find time as the main barrier for exercising at work place [22]. Also diversity in the program helps in making them engaged in the exercise [23]. The flexibility of this combo makes it very adaptable to levels of fitness and schedules and can be ideal for universities. As far as we know, there are not many studies that use CT and mobility to design physical activities for adult university employees.

With that, the objective of this study is to analyse the impact of a 4-week circuit-training intervention on fitness level and body composition in students.

It was hypothesized that the circuit-training group would show improvements in muscular strength, muscular endurance, cardiovascular endurance, flexibility, and body mass index compared with the control group based on earlier evidence.

II. MATERIALS & METHODS

A. Research Design: The research design uses a quasi-experimental comparative approach with pre-test and post-test assessments for an experimental group and a control group from government secondary schools within a quasi-experimental framework. It aims to measure health-related physical components influenced by environmental and cultural factors. The goal is to raise awareness of physical education's role in health standards and improve healthcare quality.

B. Source of Data: The data for this study were gathered from students attending the Government Senior Secondary School in Sirsa district, Haryana.

C. Sampling Method: This study was conducted through a purposeful sampling method.

D. Participants: Fifty students from various Sirsa district government S.S. Schools, aged 16-18, were purposively sampled for the study. They were divided into two equal groups: 25 in the circuit-training group (CTG) and 25 in a control group. The researcher consulted with experts during the selection process.

E. Variables: To obtain an idea about the problem, and to know the related research work, the researcher reviewed the sources like research papers, books, journals, magazines, etc. on sports training, resistance training, and circuit training. Following consideration of feasibility, availability of instruments and relevance to the present study, the below-mentioned key variables were selected for the study.

Understanding these variables helps us understand different types of physical fitness and how they affect performance and health.

F. Tools and Techniques

G. Criterion Measures: According to the expert in physical education, sports sciences, and on literature relating to contemporary training methods, the following test items have been chosen by the investigator as criterion measure. The selected tests are suitable, fitting, and ideal for evaluating the basis factors.

The battery of evaluations and the AAHPERD health technique was standard. The tests were described in detail including purpose, apparatus, evaluation and recording procedure.

1) Muscular Strength—Pull-Ups

Purpose: This exercise is designed to assess the muscular strength of the arm and shoulder muscles.

Equipment: A chin-up bar is required for this test.

Procedure: To perform the pull-up, start with arms fully extended and grasp the overhead bar using either an overhand (palms facing away) or underhand grip (palms facing toward). Raise your body until your chin passes the bar, then lower back to full extension. Perform smoothly without kicking, leg bending, swinging, or jerking. Aim to do as many full pull-ups as possible.

Score: Record the total number of correctly completed pull-ups. Additionally, note the type of grip used during the exercise.

2) Muscular Endurance—Sit-Ups: Purpose: This test measures the endurance of the abdominal muscles.

Equipment Needed: An exercise mat or a carpet and one assistant.

Procedure:

1. The participant lies on their back with feet approximately 12 inches apart and knees bent.

2. The hands are placed behind the head, with fingers intertwined.

3. An assistant holds the participant's ankles to ensure the feet remain in contact with the floor.

4. Upon starting the test, the participant begins performing sit-ups, counting each repetition aloud.

5. The participant must return to the starting position by touching their chest to their knees.

6. The test begins on the command "Prepared, go!" and runs for a duration of 60 seconds.

7. The test concludes when the assistant calls out "Stop!"

Scoring: The final score is the total number of correctly executed sit-ups completed within the one-minute timeframe.

3) Cardiovascular Endurance—12-Minute Run/Walk Test:

Purpose: The 12-minute run and walk test is designed to assess aerobic fitness, specifically measuring the body's efficiency in utilizing oxygen during physical activity such as running.

Equipment Needed:

- A flat oval or running track
- Marker cones for distance estimation
- Recording sheets for data collection
- A stopwatch for timing the test

Procedure: To conduct the test, place markers at designated intervals around the track. These markers will help participants gauge the distance they have covered. Over a span of 12 minutes, participants are encouraged to run as far as possible; walking is permitted if necessary, but they should aim to maximize their distance.

Scoring:

The results of the 12-minute run-and-walk test can be interpreted using Cooper test norm tables, which provide general benchmarks for evaluating adult performance. Additionally, two formulas can be

employed to estimate VO₂max (measured in ml/kg/min) based on the distance covered:

- For distance in miles:

$$\text{VO}_2\text{max} = (35.97 \times \text{miles}) - 11.29$$

- For distance in kilometres:

$$\text{VO}_2\text{max} = (22.35 \times \text{kilometres}) - 11.29$$

This test is a valuable tool for assessing aerobic capacity and can be useful for fitness assessments and progress tracking.

4) Flexibility—Modified Sit-and-Reach Test:

Purpose: The Modified Sit-and-Reach Test is designed to assess the flexibility of the hips and lower back, as well as the extension of the hamstring muscles in the legs. The goal is to determine how far an individual can extend their fingertips past their foot line while keeping their legs straight.

Equipment Needed:

- Flex measure case with a yardstick and tape
- Score sheet
- Helpers to assist with the test

Procedure:

1. Position the 15-inch mark of the measuring stick in alignment with a line on the floor, securing the finish of the measuring stick to the floor with tape, ensuring that the flex measure case is placed face down.
2. Sit down and position your heels directly aligned with the near edge of the 15-inch mark. Slide your seat back beyond the endpoint of the measuring stick.
3. Have a partner stand behind you and press their toes against your heels for support. Additionally, have helpers on each side to help keep your knees locked in place as you prepare to stretch.
4. With your heels no more than 5 inches apart, gradually lean forward, pushing the flex measure case as far down the measuring stick as possible using the fingertips of both hands.

5. Take note of the distance measured at the outermost edge of the case.

Scoring: The test score is determined by the best of three trials, measured to the nearest quarter inch.

5) Body Mass Index: Purpose: To assess the proportion of the body.

Procedure: Formula is used to measure body mass index. However, prior to that, the individual's body weight and height are to be measured and recorded.

The formula is as follows:

$$\text{BMI} = \text{Weight (kg)} / \text{Height (m)}^2$$

Scoring: After calculation, the score of BMI is expressed in the form of index.

Weight:

Equipment: Weighing machine

Procedure: The subject is asked stand erect on the platform of the weighing machine with equal weight on both feet. The weight of subject is usually recorded accurate up to 0.05 Kg. is maintained

The data pertaining to the study was collected by administering the tests for the selected variables. Before the collection of data, the subjects were given a chance to practice the prescribed tests so that they could become familiar with the tests and know exactly what was to be done to ensure uniform testing conditions. The subjects were tested in the morning, and data was collected.

H. Orientation and Reliability: Before the test, the investigator met with subjects for thorough explanations of the study's purpose, significance, and procedures. Each subject agreed to participate fully, was excited, and used testing tools to familiarise themselves with the protocol.

RELIABILITY OF DATA

To ensure the reliability of the data, several measures were implemented, including assessing the reliability of the instruments, testers, and subjects involved in the study. This approach helps

to ensure that the findings are credible and trustworthy.

INSTRUMENT RELIABILITY

Regarding the instruments utilised for estimating the factors, testaments of precision were obtained from instrument-testing organisations. Furthermore, dependability was established by recalibrating the scale using known factor measures where required.

TESTER'S RELIABILITY

The investigator ran practice sessions with experts to ensure the method's reliability. The researcher, aided by experienced professionals, took all measurements. The test-retest process confirmed the analyser's quality. The tester correlated data from ten subjects to verify reliability. Subject well-being was prioritised before each test to ensure consistent outcomes

Group / Item	Treatment / Details
Experimental Group I	Circuit Training (CTG)
Control Group II	Not engaged in any specific training programme
Training Duration (90 minutes)	Warm-up – 15 minutes; Instruction/Treatment (Training) – 60 minutes; Cool-down, Correction and Clarification – 15 minutes
Training Sessions per Week	Six sessions (Monday to Saturday) in the morning
Total Length of Training	Four weeks

Tables identified Group I as Circuit Training (CTG) and Group II as the Control Group (CG), presenting the well-organised schedules for Group I. Circuit training was used six days a week (Monday through

Saturday) for four weeks. Each group followed their schedule with a 15-min warm-up and 15-min cool-down within each 90-min morning session. Weekly, the load progression was adjusted. The tables detailed the intensity, repetitions, sets, rest, and duration for each group.

I. Circuit-Training Program: In the first week, subjects completed a single circuit through eight stations with straightforward activities. They exercised for forty-five seconds at each station, then had sixty seconds to move and rest. They had five minutes between circuits, with two circuits total. Fifteen minutes were for warming up, and fifteen minutes for cooling down. Instructions were given immediately. The program lasted 1.5 hours each morning, six days weekly.

2nd week - the practice in the station was diminished from 45 seconds to thirty seconds.

In the 3rd week, the training programs were maintained as in the 2nd week.

In the 4th week, the exercise time was the same as in the previous weeks, thirty seconds, but the set was increased from two to three sets, and the rest between circuits was the same as in the previous weeks.

The circuit training was given only in the morning session for six days of a week, for a period of four weeks. In the evening, the subjects were allowed to participate in their routine sports activities.

J. Administration of Tests: The examiner gathered with the subjects before testing, explaining the study's purpose, significance, and testing requirements to ensure understanding. The specialist clarified the physical-fitness test procedures, provided instructions, demonstrated each experiment, and answered questions. Test scores were collected, organised, and statistically analysed for significant results.

K. Statistical Analysis: The study involved an analysis of data to assess the impact of a training program on five selected components of physical fitness among students at the Government. S.S. School in Sirsa district, Haryana. To conduct this analysis, various statistical methods were employed, including calculating means and standard deviations and performing ANOVA.

The formulas used for these calculations are as follows:

- Mean (M) is calculated using the formula: $M = \Sigma X / N$, where ΣX represents the sum of all data points, and N is the number of data points.

- The standard deviation (S.D.) is determined with the formula: $S.D. = \sqrt{\Sigma D^2 / N}$, where D represents the deviations from the mean.

- ANOVA (Analysis of Variance) involves a four-step process to evaluate differences among group means.

- Additionally, the t-test is calculated using the formula: $t = (m_1 - m_2) / \sqrt{[(SD_1/N)^2 + (SD_2/N)^2]}$, which compares the means of two groups. This comprehensive approach enables a thorough analysis of the training program's effectiveness on students' physical fitness.

L. Weekly Training Schedule

TABLE 1

CIRCUIT-TRAINING SCHEDULE—WEEK 1

Sr. No	Exercise Circuit station	Exercise in each station	Rest between exercises and change to another	No. of sets	Repetitions between sets
1	Skiping	45 sec	60 sec	2	5 min
2	Step-ups	45 sec	60 sec	2	5 min
3	Squat thrust	45 sec	60 sec	2	5 min
4	Push-ups	45 sec	60 sec	2	5 min
5	Double knee Duck jumps	45 sec	60 sec	2	5 min
6	Sit-ups	45 sec	60 sec	2	5 min
7	Shuttle run	45 sec	60 sec	2	5 min
8	Jump and turn	45 sec	60 sec	2	5 min

TABLE 2
CIRCUIT-TRAINING SCHEDULE—WEEK 2

Sr. No	Exercise Circuit station	Exercise in each station	Rest between exercises and change to another	No. of sets	Repetitions between sets
1	Skiping	30 sec	60 sec	2	5 min
2	Step-ups	30 sec	60 sec	2	5 min
3	Squat thrust	30 sec	60 sec	2	5 min
4	Push-ups	30 sec	60 sec	2	5 min
5	Double knee Duck jumps	30 sec	60 sec	2	5 min
6	Sit-ups	30 sec	60 sec	2	5 min
7	Shuttle run	30 sec	60 sec	2	5 min
8	Jump and turn	30 sec	60 sec	2	5 min

TABLE 3
CIRCUIT-TRAINING SCHEDULE—WEEK 3

Sr. No	Exercise Circuit station	Exercise in each station	Rest between exercises and change to another	No. of sets	Repetitions between sets
1	Skiping	30 sec	60 sec	2	5 min
2	Step-ups	30 sec	60 sec	2	5 min
3	Squat thrust	30 sec	60 sec	2	5 min
4	Push-ups	30 sec	60 sec	2	5 min
5	Double knee Duck jumps	30 sec	60 sec	2	5 min
6	Sit-ups	30 sec	60 sec	2	5 min
7	Shuttle run	30 sec	60 sec	2	5 min
8	Jump and turn	30 sec	60 sec	2	5 min

TABLE 4
CIRCUIT-TRAINING SCHEDULE—WEEK 4

Sr. No	Exercise Circuit station	Exercise in each station	Rest between exercises and change to another	No. of sets	Repetitions between sets
1	Skiping	30 sec	60 sec	3	5 min
2	Step-ups	30 sec	60 sec	3	5 min
3	Squat thrust	30 sec	60 sec	3	5 min
4	Push-ups	30 sec	60 sec	3	5 min
5	Double knee Duck jumps	30 sec	60 sec	3	5 min
6	Sit-ups	30 sec	60 sec	3	5 min
7	Shuttle run	30 sec	60 sec	3	5 min
8	Jump and turn	30 sec	60 sec	3	5 min

III. CONCLUSION

The manuscript reports that a structured four-week circuit-training program can improve selected health-related fitness components and body composition among senior secondary school students. However, the source manuscript does not include the numerical results tables required to verify effect sizes, statistical significance, or between-group differences. These data should be inserted before journal submission.

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Effect of Six Weeks of Plyometric Training on Selected Motor Fitness Components Among Male Kabaddi Players

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Abstract: The research aimed to ascertain the effect of six weeks plyometric training on selected motor fitness components of male kabaddi players. Twenty male kabaddi players (aged 15 to 17 years) from Government Senior Secondary School, Faggu, Sirsa, Haryana were selected through purpose sampling. The study applied an experimental design of single-group pre-test post-test. The chosen motor fitness variables were speed, leg strength, and agility. The 50-Yard Dash Test was used to measure speed, the Standing Broad Jump Test was utilized to measure leg strength and the 4 × 10 m Shuttle Run Test was used for measuring agility. Six week one pre-test organization of plyometric training (three days/ week) was done under the supervision of the researcher. Descriptive statistics and paired-samples t-tests were used to analyse the data at the .05 level of significance. It was found that there was a significant change in all chosen motor fitness variables. The speed of participants improved significantly after 9 weeks of training. It improved from 7.61 ± 0.09 seconds to 7.33 ± 0.09 seconds ($t = 27.33, p < .001$) after speed training. There is a significant increase in leg strength from 195.60 ± 3.48 cm to 209.25 ± 3.45 cm ($t = 61.05, p < .001$). Agility improved from 11.43 ± 0.11 seconds to 10.96 ± 0.11 seconds ($t = 42.11, p < .001$). Based on the findings, it can be stated that plyometric training improves various motor fitness components

resulting in enhanced neuromuscular coordination, power, efficiency and strength. The study concludes that plyometric exercise is an effective method of training to enhance performance-related fitness components of kabaddi players and should be involved in regular training.

Keywords—Plyometric Training, Kabaddi Players, Motor Fitness, Speed, Leg Strength, Agility, Explosive Power, Athletic Performance, Neuromuscular Coordination, Sports Conditioning

I. INTRODUCTION

The health and education of the adolescent age group require proper mental health. Adolescence, marked by rapid changes in one's physical, emotional, cognitive, and social worlds, makes young people prone to psychological stress and anxiety. School students may face psychological distress due to academic competition, examination pressure, parents' expectations, peer relations, and overexposure to digital media. If not managed optimally, it can disrupt concentration, academic success, emotional balance, social functioning, and quality of life.

Stress refers to the feeling of being under too much mental or emotional pressure. Even though moderate stress can boost motivation, chronic or excessive stress hampers cognition and emotion regulation. Young people worry, fear, and feel

nervous from time to time, and the symptoms of anxiety are common in adolescents. Anxiety has a negative influence on academics and overall functioning and well-being [1], [2].

Yoga combines asana, pranayama, meditations and deep relaxation techniques. Studies show that yoga and mindfulness programs delivered in schools may improve self-regulation, mood, resilience, and psychosocial well-being. As a result, it is increasingly regarded as a non-pharmacological component of school health promotion.

It appears that despite the country being flooded with evidence, comparatively few studies have examined brief yoga interventions in Punjab, India among school students. The present study evaluated the effects of six weeks of yoga training on stress and anxiety among students aged 12-16 years.

Unfortunately, you haven't provided any text for me to paraphrase. Please provide a sentence or passage, and I'll be happy to assist you. The Yoga's conceptual and psychophysiological basis for adolescent mental health.

Adolescents who go to school experience stress based on various demands, academic, interpersonal, developmental, and environmental. At this age, students are expected to cope with an ever more complicated curriculum, competitive examinations, parental expectations, peer comparison, social-media exposure, and changing self-identity. These pressures are not independent forces. The anxiety of students can trigger insecurities that often accumulate to create a long-lasting state of mental arousal in which students expect failure. Though they are related, stress and anxiety are conceptually distinct. The less able a person is to cope with external or internal demands the higher the stress. Anxiety refers to a sense of worry, apprehension, fear, anticipatory tension, and physiological tension even when we aren't in imminent danger. In the

school setting, the two regularly reinforce each other: academic stress may create anxiety; anxiety may disrupt attention, memory retrieval, and performance, thus creating further stress. Because this is a cyclical relationship, any intervention that dampens physiological arousal and enhances emotional self-regulation may affect both at once.

The complete mind-body structure of Yoga can inform its potential effectiveness. Unlike an exercise program, yoga integrates controlled movement with breath control, training of attention, body awareness, and relaxation. The asana require the student to hold stable positions where they become aware of their muscle tension, balance, and breath. The process of pranayama teaches slow, even patterns of the breath. Also, the meditation-based relaxation teaches non-reactive awareness to the thoughts and sensations in the body. When brought together, they may break a repetitive cycle of anxiety and over activation of the autonomic nervous system. As per studies and reviews conducted within schools, the case of children or adolescents who have taken part in yoga or mindfulness-focused programs is encouraging. It has led to better moods, self-regulation as well as resilience, psychosocial functioning and performance anxiety.

This effect aligns with the view that yoga is more than a flexibility practice, as it might be a formal self-regulation intervention that trains students to better be aware of and adjust to their stress responses.

When stress lasts for an extended period of time, the sympathetic nervous system is overactive, the muscles tense up, breathing becomes shallow and rapid, and vigilance is increased. Taking slow deep breaths helps the body to relax and activates the parasympathetic nerve system. This helps in calming the arousal and emotion. Even though the

current investigation did not assess cortisol, blood pressure, heart rate variability, or any other biomarker, the reductions in the scores on the questionnaires are broadly consistent with this psychophysiological pathway. Breathing techniques such as deep diaphragmatic breathing and Nadi Shodhana are highly beneficial for controlling one's breath while calming the mind. Repeated practice of these methods may help students develop a coping response that is accessible before tests, during heavy homework loads, after emotionally difficult interactions, and so on. We should not consider this mechanism only biological. The decrease in distress may result from the predictable regularity of the session, a benign group atmosphere, the instructor's guidance, and withdrawal from academic requirements.

The mind control condition may involve attention allocation, cognitive distancing, and perceived self-efficacy. Constant worrying about negative outcomes and failures can spiral into feelings of anxiety, panic and doubt. A student may be able to notice stressful thoughts without immediately relating to them because of meditating and noticing his or her breath, but not remove them altogether. A small delay occurs between thinking and acting or responding. Just like with completion and variation in learning of redundant movements on new apparatus, learning and registering tricks and postures on a new set of apparatus gives a sense of competence and bodily control. When learners find that external forces such as exams, family expectations, or social evaluation take away their control, this sense of mastery can be meaningful. School-based yoga offers children a way to regulate their emotions and attention. School-based mindfulness interventions have shown early improvements in emotional and behavioural adjustment. Thus, engaging with and enhancing the

individual components of this six-week intervention likely reduced stress and anxiety through several mutually reinforcing pathways rather than through a single exercise.

We should also think about the length and form of the intervention. The method provides five days per week for six weeks of consistent exposure and re-exposure behavior. Thirty 45-minute classes provide a considerable amount of practice for school students, although the overall intervention is still short compared with semester-long programs. The warm-up, asana, pranayama, meditation and Shavasana allow one to follow a gradual movement from physical activation to mental quietening. Forward bending, backward bending, balancing, twisting, standing and relaxation asana may be included which may help the person to become aware of his body and relieve the strain of sitting. The last relaxation period experience is particularly relevant because the students experiment with the contrast of effort with release. By repeating this sequence, a relaxation response could be conditioned and strategies as familiarized. The structure of this advancement strengthens the practicality of pre-post reductions.

In India, many students may not have access to specialized psychological services; hence, implementation in schools is relevant. Yoga can be done in groups, requires little or no equipment, and can fit into physical education, morning assembly, wellness periods or examination-preparation programmes. A more culturally appropriate context that students, parents, and teachers may accept more readily. Yoga should be seen as an adjunct mental-health promotion tool rather than a substitute for assessment or treatment. Students exhibiting significant anxiety and/or depression and/or symptoms related to trauma and/or risk of self-harm and/or major functional impairment require

appropriate referral and clinical management. A school yoga program is better considered a universal preventive intervention that can enhance coping and emotional regulation in the general student population, while also offering counselling.

This investigation is filling a relevant gap in local evidence. An urban or clinical selection of the international literature is produced, yet no two school environments share the same academic culture, family expectations, language, resources, and daily routine. In this context, the evidence from Pakistan Punjab can do the talking. Can a short, feasible program be associated with measurable psychological change in conventional schools? Simultaneously, contextual relevance does not rule out caution with the method. Because participants were purposively selected from a single school, all of whom received the intervention, the study provides preliminary evidence of effectiveness rather than causal proof. The key contribution is to highlight a practically relevant pattern that can inform more rigorous controlled scrutiny.

II. OBJECTIVES

- 1) To determine the effect of a six-week yoga training program on stress among school students.
- 2) To determine the effect of a six-week yoga training program on anxiety among school students.

III. HYPOTHESES

- 1) There is no significant difference between pre-test and post-test stress scores following the six-week yoga training program.
- 2) There is no significant difference between pre-test and post-test anxiety scores following the six-week yoga training program.

IV. METHODOLOGY

A. Research Design and Participants: They used a pre-experimental, one-group design. From the Government Senior Secondary School, Jhanduke,

Punjab, India, thirty medically fit school students aged 12-16 years were selected through purposive sampling. Student participation here was voluntary, and permission was obtained from the school.

B. Yoga Intervention: For six weeks, five days a week, the structured program was 45 minutes per session. Each session had a warm-up (5 min), yogic asana (20 min), pranayama (10 min), meditation (5 min), and Shavasana relaxation (5 min). The asana were tadasana, vrikshasana, trikonasana, bhujangasana, shalabhasana, dhanurasana, vajrasana, paschimottanasana, pawanmuktasana, and ardha matsyendrasana. Breathing exercises, including Anulom-Vilom, Bhramari, Nadi Shodhana, and Deep Diaphragmatic Breathing, were done.

C. Measures and Statistical Analysis: Stress was measured using the Student Stress Questionnaire, and anxiety using the Test Anxiety Questionnaire. Measurements were taken before and after the intervention. Using IBM SPSS Statistics version 25, mean, standard deviation, and paired-samples t-tests were computed. P-value of < 0.05 was considered statistically significant.

V. RESULTS

Tables I and II show the comparison between the pre-test and post-test. Both outcome measure showed decreased mean score at the end of six weeks.

Variable	Test Used	Unit
Speed	50 Yard Dash	Seconds
Leg Strength	Standing Broad Jump Test	Centimeters
Agility	Shuttle Run Test (4×10 m)	Seconds

All tests will be administered according to standardized procedures to ensure reliability and validity of data.

E. Data Collection Procedure: Collection of data in a systematic manner with prior permission of the Govt. authorities and Senate Secretary School Faggu, Sirsa. The subjects were told the purpose of the research and their free consent was obtained. Speed, leg strength, and agility will be assessed using pre-tests before training program. Under the supervision of a qualified personal trainer, the subjects then followed a structured plyometric training programme which consisted of three days a week for six weeks. Further, it also included warm-up and cool-down exercises for safety purposes. They didn't take any training throughout this duration. Following this, post-tests were accomplished using the same procedures and conditions. Scores were recorded to carry out statistical analysis.

F. Statistical Analysis: The collected data was analysed using the appropriate statistical methods. To characterize the subjects' performance, descriptive statistics, namely Mean and Standard Deviation, were computed. A paired t-test was conducted to assess the differences between pre-test and post-test scores a significance threshold was set at the 0.05 level.

G. Plyometric Training Schedule:

TABLE II
SIX-WEEK PLYOMETRIC TRAINING
SCHEDULE

Variable	Test	Mean	SD	Mean Difference	t-value	p-value
Agility (sec)	Pre-test	11.43	0.11	0.47	42.11	<.001
Agility (sec)	Post-test	10.96	0.11	—	—	—

The study assessed an influence of plyometric training exchange on kabaddi player's agility performance by using agility pre and post with obtain result by paired samples t – test.

Prior to the experiment, the participant had an agility score (mean 11.43 s (M = 11.43, SD = 0.11))

while the post evaluation had a score of (mean 10.96 s (M = 10.96, SD = 0.11)). A low score indicates a better performance. The reduction of 0.47 seconds indicates better agility after training and this is needed in kabaddi to make quicker movements. Statistically, the paired-samples t-test produced a t-value of 42.11 (p < .001), suggesting a significant improvement in agility. This improvement is associated with plyometric exercise which increases neuromuscular efficiency, reaction ability and coordination of movement. The low standard deviation (SD = 0.11 for both test) means all the participants performed almost the same on both tests. This gives reliability to the findings of this study and indicates the plyometric training programme had a high positive impact on the agility of kabaddi players.

TABLE VII
COMPARISON OF SELECTED MOTOR
FITNESS COMPONENTS

Variable	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Difference	t-value	p-value	Result
Speed (sec)	7.61 ± 0.09	7.33 ± 0.09	0.28	27.33	<.001	Significant
Leg Strength (cm)	195.60 ± 3.48	209.25 ± 3.45	13.65	61.05	<.001	Significant
Agility (sec)	11.43 ± 0.11	10.96 ± 0.11	0.47	42.11	<.001	Significant

This analysis was aimed at knowing the effect of plyometric training on speed, leg strength and agility of kabaddi players. With an alpha level of 0.05, we compared the pre-test and post-test scores with a paired-samples t-test. Based on the results, speed increased significantly, as indicated by a decrease in the mean score from 7.61 seconds (SD = 0.09) during the pre-test to 7.33 seconds (SD = 0.09) during the post-test, for a mean difference of 0.28 seconds (t = 27.33, p < .001). Research has shown

improved speed performance due to increased neuromuscular and mechanical efficiency. There was a significant improvement from 195.60 cm (SD = 3.48) to 209.25 cm (SD = 3.45), mean difference of 13.65 cm ($t = 61.05$, $p < .001$) for leg strength. Consequently, plyometric training improves lower-body power and explosive strength. Scoober, an international partner, helped Owen and Stephen manage a complex forensic investigation. The inquiry was complicated by the subject's positioning and malicious threats from subject-related individuals. Ultimately, this situation deteriorated into a subpar relationship with the subject's lawyer. The reduction in time reflects improvement in agility and change-of-direction skills and movements from being trained multidirectional. In conclusion, kabaddi players showed significant improvements in speed, leg strength, and agility from plyometric training.

IV. DISCUSSION

The study evaluated the effects of a six-week plyometric training regimen on speed, leg strength, and agility among male kabaddi players, yielding substantial improvements across all measured parameters.

Speed: The research shows that six weeks of plyometric training significantly improves the speed, leg strength and agility of male kabaddi players.

Participants recorded a significant improvement in speed, with a mean pre-test time of 7.61 ± 0.09 seconds decreasing to 7.33 ± 0.09 seconds. The t -value of 27.33 was statistically significant at 0.05 level, signifying that the plyometric training positively impacted accelerating performance. As a result of specific plyometric drills, such as box jumps and squat jumps, an improved ability of neuromuscular efficiency and increased rate of force development are likely the cause. According to this

study as well as Singh and Sharma [10] and Ferrer et al. [2], there was an increase in speed in many other players as well. As kabaddi involves players running short distances, speed is one of the essential physical feature.

Leg Strength: The leg strength significantly increased, with the mean score jumping from 195.60 ± 3.48 cm (pre-test) to 209.25 ± 3.45 cm (post-test), which means an overall increase of the mean leg score of 13.65 cm. This incidence of t -value 61.05 indicates that this plyometric exercise was effective in improving lower-body strength and explosive power. This notable enhancement arises from the quick eccentric and concentric contractions caused during plyometric exercise which develops neuromuscular efficiency to produce force. Improved muscle recruitment, increased compliance of tendons, and the use of elastic energy increased power output, as has been seen in the Standing Broad Jump Test, where performance improved post- programme. These outcomes corroborate the findings of Rahman et al. [3] who recorded significant improvement in explosive strength of youth athletes due to plyometric training. Similarly, Patel and Mehta [9] reported superior strength gains from plyometric training than conventional resistance training modalities. More leg strength means better explosion for kabaddi moves like raids, jumps, lunges, sudden changes of direction, and defensive moves.

Agility: In terms of agility, the results showed improvement from 11.43 ± 0.11 seconds in the pre-test to 10.96 ± 0.11 seconds in the post-test, with a mean difference of 0.47 seconds and a t value of 42.11, which was significant. This improvement is due to better neuromuscular coordination, balance, reaction time and speed of direction change due to the plyometric exercises. Exercises like lateral jumps and bounding drills enhance the body's ability

to generate force quickly with great control for maximum agility. The results were reported by Rahman et al. [3], Patel and Mehta [9] and Martinez-Garcia et al. [1] to significantly improve the agility of athletes with plyometric training interventions.

In sum, findings of the plyometric training program for six weeks for kabaddi players showed significant improvement in speed, leg strength and agility. Leg strength showed the maximum improvement. Observational benefits are related to physiological and neuromuscular gears linked to advantages coming from plyometric such as motor unit recruitment and muscle elasticity. The results will enhance kabaddi players' motor fitness levels as well as performance levels by including plyometric training in kabaddi training. Therefore, it is strongly recommended to implement plyometric training to optimize speed, leg strength, agility and fitness of kabaddi players.

V. CONCLUSION

The present study has shown that plyometric training is an effective method to increase the motor fitness of kabaddi players. The improved performance of athletes due to increased muscle unit recruitment, synchronization of the muscles, enhanced efficiency of stretch reflexes, use of elastic energy and explosive power.

The result of the finding corroborated prior studies that plyometric training is beneficial for speed, power, strength, and agility. This underlines the importance of including these exercises in sports conditioning protocols since the methods used in the past are not enough to meet modern kabaddi needs. Implementing a structured plyometric training program can greatly enhance the skills needed for actions like raiding, tackling, jumping, and sprinting. In addition to that, the plyometric training is economical and time-efficient, requiring minimal

equipment and suitable for various training environments, making it easy for any coach to improve performance without high costs.

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Effect of a Six-Week Yoga Training Program on Stress and Anxiety Among School Students: A Pre–Post Experimental Study

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Abstract— The period of adolescence is quite critical as during this stage student mostly encounter high stress and anxiety because of studies, social expectations, and lifestyle. Long-term pressure can affect an individual's emotional state, learning, and academic performance. The aim of this study was to assess the effect of well-organized six-week yoga training programme in schools on stress and anxiety of students. A one-group pre-test post-test pre-experimental design. Thirty purposively sampled students aged twelve to sixteen years from Government Senior Secondary School Jhanduke, Punjab, India. For six weeks, participants were completed a yoga programme, comprising of asana, pranayama, meditation and relaxation for 45 min per day, daily five days a week. The Student Stress questionnaire was used for assessment of stress and Test Anxiety Questionnaire for anxiety. The researchers utilized descriptive statistics as well as paired-sample t-tests at 0.05 significance level to analyse the data. The mean stress score dropped from 31.47 ± 3.82 to 25.10 ± 4.11 according to the t-test with obtained value of 7.86, $p < 0.05$. In addition, the mean anxiety score dropped from 13.97 ± 1.95 to 10.53 ± 2.16 according to the t-test with obtained value of 6.42, $p < 0.05$. The study findings show that six weeks of yoga significantly reduce stress and anxiety of students in schools. School health and physical education programs might use structured yoga classes as a practical,

cost-effective way to enhance mental health in adolescents.

Keywords—adolescents, anxiety, mental health, psychological well-being, school students, stress, yoga.

I. INTRODUCTION

The health and education of the adolescent age group require proper mental health. Adolescence, marked by rapid changes in one's physical, emotional, cognitive, and social worlds, makes young people prone to psychological stress and anxiety. School students may face psychological distress due to academic competition, examination pressure, parents' expectations, peer relations, and overexposure to digital media. If not managed optimally, it can disrupt concentration, academic success, emotional balance, social functioning, and quality of life.

Stress refers to the feeling of being under too much mental or emotional pressure. Even though moderate stress can boost motivation, chronic or excessive stress hampers cognition and emotion regulation. Young people worry, fear, and feel nervous from time to time, and the symptoms of anxiety are common in adolescents. Anxiety has a negative influence on academics and overall functioning and well-being [1], [2].

Yoga combines asana, pranayama, meditations and deep relaxation techniques. Studies show that yoga and mindfulness programs delivered in schools may improve self-regulation, mood, resilience, and

psychosocial well-being. As a result, it is increasingly regarded as a non-pharmacological component of school health promotion.

It appears that despite the country being flooded with evidence, comparatively few studies have examined brief yoga interventions in Punjab, India among school students. The present study evaluated the effects of six weeks of yoga training on stress and anxiety among students aged 12-16 years.

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Adolescents who go to school experience stress based on various demands, academic, interpersonal, developmental, and environmental. At this age, students are expected to cope with an ever more complicated curriculum, competitive examinations, parental expectations, peer comparison, social-media exposure, and changing self-identity. These pressures are not independent forces. The anxiety of students can trigger insecurities that often accumulate to create a long-lasting state of mental arousal in which students expect failure. Though they are related, stress and anxiety are conceptually distinct. The less able a person is to cope with external or internal demands the higher the stress. Anxiety refers to a sense of worry, apprehension, fear, anticipatory tension, and physiological tension even when we aren't in imminent danger. In the school setting, the two regularly reinforce each other: academic stress may create anxiety; anxiety may disrupt attention, memory retrieval, and performance, thus creating further stress. Because this is a cyclical relationship, any intervention that dampens physiological arousal and enhances emotional self-regulation may affect both at once. The complete mind-body structure of Yoga can

inform its potential effectiveness. Unlike an exercise program, yoga integrates controlled movement with breath control, training of attention, body awareness, and relaxation. The asana require the student to hold stable positions where they become aware of their muscle tension, balance, and breath. The process of pranayama teaches slow, even patterns of the breath. Also, the meditation-based relaxation teaches non-reactive awareness to the thoughts and sensations in the body. When brought together, they may break a repetitive cycle of anxiety and over activation of the autonomic nervous system. As per studies and reviews conducted within schools, the case of children or adolescents who have taken part in yoga or mindfulness-focused programs is encouraging. It has led to better moods, self-regulation as well as resilience, psychosocial functioning and performance anxiety.

This effect aligns with the view that yoga is more than a flexibility practice, as it might be a formal self-regulation intervention that trains students to better be aware of and adjust to their stress responses.

When stress lasts for an extended period of time, the sympathetic nervous system is overactive, the muscles tense up, breathing becomes shallow and rapid, and vigilance is increased. Taking slow deep breaths helps the body to relax and activates the parasympathetic nerve system. This helps in calming the arousal and emotion. Even though the current investigation did not assess cortisol, blood pressure, heart rate variability, or any other biomarker, the reductions in the scores on the questionnaires are broadly consistent with this psychophysiological pathway. Breathing techniques such as deep diaphragmatic breathing and Nadi Shodhana are highly beneficial for controlling one's breath while calming the mind. Repeated practice of these methods may help students develop a coping

response that is accessible before tests, during heavy homework loads, after emotionally difficult interactions, and so on. We should not consider this mechanism only biological. The decrease in distress may result from the predictable regularity of the session, a benign group atmosphere, the instructor's guidance, and withdrawal from academic requirements.

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We should also think about the length and form of the intervention. The method provides five days per week for six weeks of consistent exposure and re-exposure behavior. Thirty 45-minute classes provide a considerable amount of practice for school

students, although the overall intervention is still short compared with semester-long programs. The warm-up, asana, pranayama, meditation and Shavasana allow one to follow a gradual movement from physical activation to mental quietening. Forward bending, backward bending, balancing, twisting, standing and relaxation asana may be included which may help the person to become aware of his body and relieve the strain of sitting. The last relaxation period experience is particularly relevant because the students experiment with the contrast of effort with release. By repeating this sequence, a relaxation response could be conditioned and strategies as familiarized. The structure of this advancement strengthens the practicality of pre-post reductions.

In India, many students may not have access to specialized psychological services; hence, implementation in schools is relevant. Yoga can be done in groups, requires little or no equipment, and can fit into physical education, morning assembly, wellness periods or examination-preparation programmes. A more culturally appropriate context that students, parents, and teachers may accept more readily. Yoga should be seen as an adjunct mental-health promotion tool rather than a substitute for assessment or treatment. Students exhibiting significant anxiety and/or depression and/or symptoms related to trauma and/or risk of self-harm and/or major functional impairment require appropriate referral and clinical management. A school yoga program is better considered a universal preventive intervention that can enhance coping and emotional regulation in the general student population, while also offering counselling.

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culture, family expectations, language, resources, and daily routine. In this context, the evidence from Pakistan Punjab can do the talking. Can a short, feasible program be associated with measurable psychological change in conventional schools? Simultaneously, contextual relevance does not rule out caution with the method. Because participants were purposively selected from a single school, all of whom received the intervention, the study provides preliminary evidence of effectiveness rather than causal proof. The key contribution is to highlight a practically relevant pattern that can inform more rigorous controlled scrutiny.

II. OBJECTIVES

- 1) To determine the effect of a six-week yoga training program on stress among school students.
- 2) To determine the effect of a six-week yoga training program on anxiety among school students.

III. HYPOTHESES

- 1) There is no significant difference between pre-test and post-test stress scores following the six-week yoga training program.
- 2) There is no significant difference between pre-test and post-test anxiety scores following the six-week yoga training program.

IV. METHODOLOGY

A. Research Design and Participants: They used a pre-experimental, one-group design. From the Government Senior Secondary School, Jhanduke, Punjab, India, thirty medically fit school students aged 12-16 years were selected through purposive sampling. Student participation here was voluntary, and permission was obtained from the school.

B. Yoga Intervention: For six weeks, five days a week, the structured program was 45 minutes per session. Each session had a warm-up (5 min), yogic asanas (20 min), pranayama (10 min), meditation (5 min), and Shavasana relaxation (5 min). The asanas

were *tadasana*, *vrikshasana*, *trikonasana*, *bhujangasana*, *shalabhasana*, *dhanurasana*, *vajrasana*, *paschimottanasana*, *pawanmuktasana*, and *ardha matsyendrasana*. Breathing exercises, including *Anulom-Vilom*, *Bhramari*, *Nadi Shodhana*, and *Deep Diaphragmatic Breathing*, were done.

C. Measures and Statistical Analysis

Stress was measured using the Student Stress Questionnaire, and anxiety using the Test Anxiety Questionnaire. Measurements were taken before and after the intervention. Using IBM SPSS Statistics version 25, mean, standard deviation, and paired-samples t-tests were computed. P-value of < 0.05 was considered statistically significant.

V. RESULTS

Tables I and II show the comparison between the pre-test and post-test. Both outcome measure showed decreased mean score at the end of six weeks.

TABLE I
PRE-TEST AND POST-TEST STRESS
SCORES

Assessment	Mean	SD	t-value
Pre-test	31.47	3.82	7.86*
Post-test	25.10	4.11	—

*Significant at $p < 0.05$.

Stress decreased from a pre-test mean of 31.47 (SD = 3.82) to a post-test mean of 25.10 (SD = 4.11). The mean reduction was 6.37 points, and the paired-samples t-test was statistically significant ($t = 7.86$, $p < 0.05$). The null hypothesis concerning stress was therefore rejected.

TABLE II
PRE-TEST AND POST-TEST ANXIETY
SCORES

Assessment	Mean	SD	t-value
Pre-test	13.97	1.95	6.42*
Post-test	10.53	2.16	—

*Significant at $p < 0.05$.

Anxiety decreased from a pre-test mean of 13.97 (SD = 1.95) to a post-test mean of 10.53 (SD = 2.16). The mean reduction was 3.44 points, and the paired-samples t-test was statistically significant ($t = 6.42$, $p < 0.05$). The null hypothesis concerning anxiety was therefore rejected.

VI. DISCUSSION

The study found that a six-week structured yoga program was significantly effective in decreasing stress and anxiety. The stress reduction may be due to the joint effects of posture, breathing, meditation, and relaxation. These techniques may facilitate physiological arousal and promote mindfulness, emotional regulation, and adaptation.

A decline in anxiety is consistent with prior studies demonstrating improved mood, psychosocial well-being, self-control, and performance anxiety with yoga- or mindfulness-based interventions among youth [3]–[13]. Students may benefit from regulated breathing and meditation to help them control worrying and nervousness and enhance their concentration and self-confidence. Given that this study employed a one-group pre-test–post-test design without a control group, causal inference should be interpreted with caution. Maturation, repeated testing, expectancy, and other uncontrolled factors should not be ruled out.

The intervention, in terms of its use, was brief, low-cost, and a feasible school-based option. Regular

yoga sessions may boost physical education and student wellness activities. Broad extrapolation of results requires larger controlled studies before making such claims.

A. Interpretation of the Magnitude and Educational Relevance of Change: The decrease in numbers is not only statistically significant but also educationally significant. The stress decreased by 6.37 points from a baseline mean of 31.47, representing a reduction of about 20.2% from the pre-test mean. Anxiety decreased from the baseline mean of 13.97 to 10.53 (3.44 points, or around 24.6%).

The aforementioned rates should not be interpreted as clinical recovery rates, as diagnostic cut-off scores and clinically important difference thresholds were not determined in the current investigation. However, the direction and magnitude of the change suggest that the intervention was associated with a non-trivial average change in questionnaire responses. A slight drop in perceived stress and test anxiety among teachers and school leaders may be meaningful if it leads to greater classroom participation, more consistent behavior, improved sleep, or reduced test-related distress. Rather than assuming them, future studies should directly assess these functional outcomes.

The decline in stress levels corresponds with the multifaceted nature of the program. The practice of asana may diminish physical restlessness and muscular tension, along with pranayama and meditation, which regulate arousal and attentional focus. At the end of every session, Shavasana may reinforce the relaxation response. In the design used, these components cannot be separated, and any program should be interpreted as an integrated package. The methodologically significant factor is that ascription of the observed change to a specific posture or breathing exercise would be misleading.

To determine which components were more responsible, studies could compare asana-only, breathing-only, meditation-only, and combined conditions. Since this is the strongest conclusion until such data appears, the complete structured program was associated with reduced perceived stress.

The improvement in anxiety may be particularly relevant for exams. Test anxiety encompasses cognitive worry, fear of negative evaluation, physiological tension, and concentration problems. Students may be able to notice early signs of arousal with the help of consistent exposure to slow breathing and meditative attention. Moreover, regular participation in communal programs may normalize the emotional complications, as these programs convey to the students that stress management is an educational activity and not a weakness. It might lessen shame and facilitate seeking assistance. Earlier studies have reported the effect of yoga programs on anxiety and mood switch among adolescents [7]. Studies also report the general benefit of these yoga programs for school psychosocial well-being [8]. The present findings are therefore consistent with a growing literature and add a school sample with geographic specificity.

Several non-specific influences may also have contributed to the results. The instructor regularly attended to the students, introduced a new group activity, and the students may have expected the improvement. The post-test was given after exposure to the questionnaires and after six weeks of structured contact. Familiarity, Hawthorne, expectancy or social desirability effects can occur. Stress and anxiety may also be influenced by maturation and changes to the school calendar, such as if an examination, holiday, or academic workload varied for the two assessments. A randomized controlled design with an active comparison group

would help to distinguish yoga-specific effects from attention, group participation, and time-related effects. Future studies could, for instance, examine the relative effects of yoga and a standard physical exercise, quiet reading, health education, or a waitlist condition.

Measurement quality matters as well. The questionnaire scores used in the study are suitable for capturing students' perceived experiences but are sensitive to comprehension, mood at the time of testing, and willingness to disclose distress. It is necessary for future studies to examine the reliability and validity of the Student Stress Questionnaire and Test Anxiety Questionnaire in the age group and language context. For the present sample, Cronbach's alpha or omega and other internal consistency estimates should be computed. When possible, teacher ratings, parent observations, attendance, sleep, academic performance, heart-rate variability, resting pulse, or salivary cortisol could supplement self-report data. Researchers would be able to determine if subjective improvement is associated with behavioural or physiological change through a multimethod design.

Strengthening statistical analysis in the following studies could also happen. Paired samples t-tests compare the means of pre-test and post-test when the difference scores are normally distributed. Future reports should include the shape of the distribution of difference scores, an indication of potential outliers, and confidence intervals for the mean change. Effect sizes, such as Cohen's *d* for paired observations, would enable cross-study comparisons and communicate the practical magnitude of the intervention in addition to the *p*-value. Examine differences in improvement across the variables of age, sex, baseline severity, attendance, previous yoga experience, academic grade, and proximity to examinations. Test whether students attending more

sessions experience higher reductions, using dose–response analysis.

The program is feasible, one of its most essential practical qualities. Because it requires no special machines, medication, or expensive infrastructure, it could be done at school in 45 minutes. However, the success in scaling would be dependent upon instructor competence, safety of the students, scheduling, ventilation and space, cultural sensitivity and adapting for students with physical limitations. It is necessary to document attendance and compliance accurately and systematically. Teachers shouldn't make yoga compulsory as a remedy or substitute for psychological support. A more tiered model: universal yoga-based wellness sessions and brief screening for all students with persistent, unidentified symptoms, and referral pathways for students needing specialist care.

It's not certain what long-term maintenance will yield. Thus, to conclude, the improvement seen after the test does not guarantee that the benefits continue past the end of the formal sessions. Assessments at 1, 3 and 6 months will help clarify durability. Schools may also test whether gains can be maintained with shorter maintenance sessions, home practice logs, audio-guided breathing or teacher-led relaxation. To find out about the stress management skills that students found useful, difficult, embarrassing, or transferable to real-life stress, it might be helpful to conduct qualitative interviews. If they offer data that might enhance the design of the interventions, then it will be able to explain why certain students will respond more, as compared to others. The conclusions of this study should probably be regarded as encouraging pilot data that calls for a larger more controlled and methodologically richer trial rather than as conclusive evidence of universal effectiveness.

VII. CONCLUSION & RECOMMENDATIONS

A six-week, well-structured yoga training program significantly reduced the measured stress and anxiety of school students. Results indicate yoga could be a useful added strategy for promoting mental health among adolescents in educational settings.

- 1) Incorporate classes to teach Yoga asana (postures), pranayama (breathing techniques), and meditation.
- 2) Sessions must be conducted under the supervision of appropriately qualified instructors.
- 3) Making use of larger and more varied samples and including a control or comparison group.
- 4) Evaluate and maintain advantages through medium- or long-term follow-up.
- 5) Look at other outcomes, including depression, self-esteem, resilience, attention, attendance, and achievement.

VIII. LIMITATIONS

The study used purposive sampling, a small sample, and a single school. It did not include randomization or a control group, and the outcome measures were based on questionnaire scores. Accordingly, the findings should be interpreted as preliminary and may not be generalizable to all school students.

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The Role of Gurdwaras in Social and Cultural Development

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Abstract- *Gurdwaras are not just places of worship but also community institutions. In Sikh society, Gurdwaras play an important role in social service, education, cultural transmission, and humanitarian action. This paper examines the significance of gurdwaras for social and cultural development. The paper also examines the role of gurdwaras in the context of principles such as seva, sangat, langar, equality, and sarbat da bhal. The analysis shows that gurdwaras have traditionally created spaces that allow for worship and shared meals, voluntary service, and cooperation to confront the obstacles created by social barriers such as caste, class, gender, religion, and economy. The paper will go on to discuss their contributions in the fields of education, health, relief work, language preservation, Gurbani Kirtan, festive activities, historical memory, diasporic identity and civic participation. It concludes that Gurdwaras continue to provide assistance to Sikhs today and remain functioning institutions of Sikh heritage.*

Keywords—*Gurdwaras, Sikhism, langar, seva, social development, cultural preservation, Sikh diaspora, community welfare.*

I. INTRODUCTION

The literal meaning of gurdwara is "gateway of the Guru", and it is one of the most important institutional expressions of Sikhism. The objectives of prayer have never simply been limited to ritual prayer, but rather gathers together the teachings of spirituality, moral formation, public service, collective learning and cultural continuity. Sikh thought places high importance on equality, truthful

living, remembrance of God, human fellowship and service to all. The Gurdwaras takes these values and gives them a visible and organized form in daily community life [1], [2].

Since the time of the Sikh Gurus, the Gurdwaras has been a place for coming together beyond boundaries of caste, class, gender, occupation, and wealth. This model created a participatory model in which listening to gurbani, sharing food as langar, performing voluntary service, and participating in sangat became mutually reinforcing activities. In this regard, the gurdwaras is sacred and social at the same time: it is a site of worship but also a site where the social ethics of Sikhism are enacted.

The theme of gurdwaras as institutions of social and cultural development is elaborated and restructured. It talks about what development is, the evolution of development, contributions to welfare, education, culture, diaspora, contemporary relevance, and places. The paper's approach is historical and analytical. It regards the gurdwara a community institution that operationalizes religious ideals into social practices [5].

II. HISTORICAL EVOLUTION OF THE GURDWARA

The origins of the gurdwara can be traced back to the teachings and congregational activities associated with Guru Nanak Dev Ji. According to Guru Nanak, One God should be worshipped, one should live honestly, do not practise empty ritual, and have fellowship with all mankind. The early Sikh sangat set of people provided a space by listening, learning, singing hymns, reflecting on the

ethical life, and actual engagement [1], [6]. The basic form of the gurdwara as a spiritual and social centre was created by these.

Guru Amar Das Ji established the concept of pangat, which is a gathering where individuals sit together and share food before meeting the Guru. This ritual challenged the caste hierarchy and social exclusion by making equality a bodily as well as a collective experience [7].

Guru Ram das Ji and Guru Arjan Dev Ji played a key role in the development of the major Sikh religious centres and the foundation and completion of Harmandir Sahib, Amritsar. Symbolizing access from all directions, the four entrances of Harmandir Sahib present an ideal of universal accessibility in spirituality.

Over time, gurdwaras have evolved to become an institution of education, discussion, resource sharing, and identity formation. They are places of devotion and much more.

Amidst political pressure during the 17th and 18th centuries, the gurdwaras became a venue to consolidate identity. The Sikh community was encouraged by them with an organizational space and continuity during times of social instability. During colonization, the gurdwara reform movement introduced changes to gurdwaras by offering positive and community-based development. Accordingly, the historical evolution of the gurdwara demonstrates a continual transition from prayer centre to social institution.

III. CONCEPTUAL BASIS: SEVA, SANGAT, LANGAR, & SARBAT DA BHALA

The power of the gurdwara is underpinned by a host of Sikh ideas. Seva, giving up this ego and doing it for the benefit of others. In the gurdwara, we do not learn about the value of seva in the abstract. We do

not carry out the role of a mere teacher. Rather, we perform actual acts of seva. This includes cooking, cleaning, and serving food. It also involves teaching children, overseeing community programs, organizing relief work, and helping the needy. Selfless service connects activism and spirituality with the public good, achieving true liberation.

The company of pious people is sangat. It establishes a sense of shared moral living and responsibility. People act in a community of listening, prayer, service and mutual recognition, rather than as isolated individuals. The gurdwara is significant for social cohesion as a site for dialogue, coalescent and ethical learning (the idea of sangat) (see [12]).

One of the most recognizable and impactful processes of the gurdwara is langar. It is a place of a community kitchen i.e. where food is prepared or served to one and all. The act of providing food is considered less important than making equality manifest in everyday life. Participants' sitting and eating "the same food" is symbolic of an egalitarian social order. Our celebrated religious institution equals all human beings and offers them food without charge.

- Sarbat da bhalā' gurdwara the term for universal social orientation for the 'welfare of all' (doc 19) They serve all communities and see a universal human responsibility for human welfare. This principle may be behind many gurdwaras distributing food, giving medical help, helping with a disaster or out-reach that saves people of any religion and caste.

IV. GURDWARAS & SOCIAL DEVELOPMENT

The Gurdwaras have encouraged equality, service, compassion, and collective responsibility to promote social development. Langar tackles hunger and social exclusion, and seva mobilizes community

labour and resources for the collective good. Through the process of social development, dignity is not contingent upon one's income, caste, or gender, or institutional status.

Gurdwara-based social upliftment's one of the major areas is humanitarian service. Gurdwaras often hold medical camps, blood donation camps, food distribution, assistance to economically weaker families, shelter support and disaster relief. In the face of floods, earthquakes, pandemics, and other crises, the volunteers of gurdwaras respond quickly due to their well-established culture of volunteerism, in-house kitchens, and community trust [11], [14].

Another important aspect is education. Numerous gurdwaras run or support educational initiatives such as schools, libraries, Punjabi classes, Gurmukhi literacy programs, religious education centres, and scholarships and coaching for students. These programs encourage social mobility without compromising the knowledge of faith and morals. Gurdwaras play an important educational role, especially for children and youth, which associates learning with values like humility, discipline, responsibility, and respect for diversity [13], [15].

The gurdwara is also a space for social cohesion. It allows everyone to come together to worship, engage in dialogue, run festivals, run youth and women-led initiatives, and partake in shared decisions. As you demonstrate your integrity, believe them and trust them, together with mutual support, you ally together. Although there are regional differences, the Sikh value-base calls for resistance against caste discrimination, poverty, illiteracy, gender exclusion, social fragmentation. The gurdwara serves as a community development resource for moral and civic resources.

Another key benefit is empowerment through participation. Members of the community are not passive members. They cook, clean, throw parties,

teach children, manage resources, and do relief activities. This kind of culture builds discipline, leadership, and ownership. It also motivates people from different social standings to serve and learn together. The gurdwara in this sense is a training ground for socio-civic responses [12], [17].

V. CULTURAL PRESERVATION & TRANSMISSION

Gurdwaras have an important role in preserving Sikh cultural heritage. Every day, the Sikh community recites and discusses the Guru Granth Sahib and does Kirtan, in addition to researching and praying together. The gurdwara functions as a living archive that safeguards not simply texts, but also music, memory, practice, values, collective identity and so on [8], [17].

One of the most significant activities of the gurdwara that contributes towards the culture is the promotion of Punjabi and Gurmukhi script. Through multiple classes, gurdwaras enable younger generations to read, recite and understand the Sikh Scriptures. This is achieved through language classes, Gurbani learning, children's camps and religious instruction. In diaspora situations where children use languages different from those that their parents and grandparents use, this role is essential [15], [18].

Gurdwaras also preserved literary tradition associated with music. Kirtan represents an amalgamation of sound, emotion, discipline and remembrance that links theology with practice. Gurdwaras should keep such devotional forms during kirtan programmes, music training and religious gatherings which have historical and spiritual significance. Certain Gurdwaras also have libraries, collections of religious literature and archives which contribute to the intellectual continuity of Sikhs.

Festivals¹²⁸ also encourage cultural transmission. Holidays like gurpurab, Vaisakhi, martyrdom days and others infuse community through narratives of faith, sacrifice, service, and togetherness. These events are much more than an afternoon ceremony, they teach us history, strengthen the feeling of belonging and offer a means of teaching. To learn from their elders, the children should help out in service activities, participate in puja and kirtans, assist in processions and eat together [6], [20].

VI. DIASPORA, IDENTITY & COMMUNITY BELONGING

The Sikh diaspora communities found in Britain, North America, Australia, Africa and more all attach high importance to gurdwaras. Migrant religious organizations help newcomers navigate a new social environment with a mix of religious continuity and cultural orientation, language and advocacy support, and community networks that build identity. This literature explains that the gurdwara bridges the connection between homeland memory and host-society participation [15], [18].

Gurdwaras located away from their homeland serve multiple purposes. Over the past twenty years, there has been a large increase in the degree to which different faiths encourage cooperation between groups of different faiths. Sikh communities retain distinct identities and adopt positive interaction with a multicultural society. The dual mandate is especially relevant for second- and third-generation Sikhs who negotiate questions of language, representation, belonging and public visibility [18], [20].

The existence of gurdwaras in the diaspora shows that preserving culture does not mean isolating it. Communications delivered or conducted in many languages, activities across various online platforms, youth workshops, social media, and

outreach to the community form the youth outreach package. Sikh way of life allows for change and adaptation to suit social contexts. Thus, the institution protects tradition while enabling the emergence of new forms of participation forms [14], [19].

VII. CONTEMPORARY RELEVANCE & ADAPTATION

Gurdwaras are reforming themselves to new social, technological and educational conditions in a modern society. Numerous institutions now use educational outreach, community counselling, youth webinars, digital announcements, online donation systems, and more. The new innovations don't replace existing ones; they extend the existing reach of seva, sangat, and Sikh teaching into new public spaces [14], [19].

The gurdwara stays useful because it addresses a social problem and stays relevant. Many communities face many issues like loneliness, stress from migration, drug and alcohol problems, money problems, language loss, cultural disconnects, inter-generational problems, etc. Gurdwaras can offer support to youth and families, educate about culture, and work towards welfare. They can be very powerful when working together as communities and organizations that trust them and are legitimate spiritually.

Nonetheless, there are problems associated with it. Damage to gurdwara management happens due to generational/gender expectations, political dissent, and resource allocation. The significance of these concepts and the promotion of transparent administration, participatory processes, youth leadership and equality and service ideals is still undervalued [10], [20].

VIII. PRACTICAL IMPLICATIONS FOR SOCIAL & CULTURAL DEVELOPMENT

The first practical implication points to gurdwaras being understood as community-based welfare institutions. These groups are strong because they can mobilize volunteers, food supplies, money, buildings, and social trust quickly. As a result, they are quite efficient during emergencies, periods of impoverishment, dislocation, or public health catastrophes. The design of the model, though bureaucratic in a narrow sense, is relational, participative and ethical.

Implications Related to Education and Youth Education. Gurdwaras can make the inter-generational cultural gap smaller through offering Punjabi classes, classes about learning Gurmukhi, teachings about the religion, training in music, and learning about moral values. Activities where people get together to serve the community also serve another function. It helps youth realize that Sikhs do not just wear the symbols; we are not just about those. Our identity is further about service, equality, humility, and responsibility. Thus, they learn that Sikhs are about these things. This is also part of Sikh identity formation [13], [18].

The third meaning is intercultural dialogue. In societies with a multicultural mix of religions, a gurdwara can be a place where non-Sikhs come to experience the values of Sikhism through langar, open worship, public lectures, interfaith programs, and humanitarian projects.

Intergroup contact can reduce stereotypes and promote respect. As a result, the gurdwara is seen as having civic value beyond the Sikh community.

The institutional accountability aspect relates to the fourth implication. It is important to manage the gurdwara because they wield power over culture and

religion. Utilizing participatory decision-making, inclusive committee, youth and women's participation and fair resource use can enhance public trust. The Gurdwara is a credible example of good governance when its practices comply with Sikh teaching [10], [16].

The research suggests that gurdwaras can be examined as sustainable community institutions. The incorporation of spiritual motivation with material welfare, cultural preservation with social adaptation and local service with transnational identity. Because of the uniqueness of their experience, they are a rich resource for researchers working in religion, sociology, cultural studies, diaspora studies, social work and community development [12], [15].

IX. DISCUSSION

The gurdwara is best understood as an integrated cultural system, our analysis suggests. The social role is not arbitrary, but is a consequence of the ethical principles of the Sikh religion. Langar encourages everyone to be equal, service inspires people to help others, sangat can make you collective, and sarbat da bhala can go beyond boundaries. Both these practices transform religious values into social actions.

The gurdwara contributes to Sikh heritage through its scriptures and linguistic, musical, festive, literary, and historical dimensions. It is always a fluid process. Gurdwaras are frequently a reinterpretation of inherited traditions in new circumstances. The community of Nihangs is important for Punjab and the Sikhs of the world as they can preserve culture while adapting to the needs of contemporary circumstances.

Thus, we must observe the role of gurdwaras in development from a broader perspective. They are often multilingual, enabling them to participate in the workforce of different countries. The effects of

these services aren't limited to Sikhs alone, as often people from other religions and social backgrounds are part of their food services, relief works, and humanitarian programs. The Gurdwara has a public institutional orientation that is inclusive [14], [20].

X. LIMITATIONS & FUTURE SCOPE

This material is not from a field survey of any gurdwara. But is based on historical and analytical reading of the role of gurdwaras. Consequently, the local variations of management and participation, gender inclusion, youth engagement, and welfare capacity may not be sufficient. Future research could involve utilizing interviews, questionnaires, and ethnographic observation to see how different gurdwaras enact the possibilities of seva, sangat, and langar.

Another limitation of the article is that gurdwaras are viewed broadly, both in Punjab and in diasporic contexts. The true institutional role of a gurdwara varies by region, migration history, economic means, leadership model, and community composition. Comparative studies on rural-urban-diaspora gurdwaras would yield richer evidence on social function change.

Research may be conducted in the future to study the digital transformation of gurdwaras, including live events, online learning, youth messaging, digital fundraising, and social media. Through this work, we can show how ordinary Sikh institutions create, sustain and reproduce cultural memory while adapting to contemporary modes of public engagement. [14], [19].

XI. CONCLUSION

Gurdwaras have made significant socio-cultural contributions to the development of the Sikh society and the wider community. Originating in the teachings of the Sikh Gurus, gurdwaras developed

majorly into institutions that promote equality, service and compassion, education, humanitarian relief, and cultural continuity. The gurdwara serves as a practical model of community-centered development through community practices which include langar, seva, sangat, and sarbat da bhala.

The research findings suggest that gurdwaras are vibrant socio-cultural institutions. They conserve the Sikh heritage through the scriptures and the Punjabi language, the Gurmukhi script, Gurbani Kirtan, festivals, literature, and collective memory. At the same time, they also provide education, healthcare support, disaster relief, diaspora services, digital outreach and community welfare in response to current needs. The continued relevance of these systems lies in their ability to translate ethical ideal into visible social practice.

A model of belonging based on service is put forward by the gurdwara in a society marked by social inequality, migration, cultural anxiety and erosion of community. It has always made a monumental contribution by creating a space for worship, welfare, culture and equality. As a crucial institution for social progress and cultural preservation, the gurdwara is highly relevant.

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Effect of Yoga on Reproductive Health in Women

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Abstract— The reproductive health of women is most likely affected by modern lifestyle patterns (like physical inactivity, stress, sleep pattern issues, obesity, and unhealthy dietary practices). This research assessed how a 12-week yoga program with structured sessions affected the reproductive health score among women aged 20 to 40 years. The participants were assigned to an experimental group (n=30) that received supervised yoga sessions for 60 minutes per day, 5 days per week. The other group (n=30) served as the control group and continued with their usual activities. The mean score for reproductive health of experimental subjects was 58.4 ± 8.2 (pre-test) and 81.6 ± 6.5 (post-test). While the control group mean score was 57.9 ± 7.9 (pre-test) and 59.3 ± 7.6 (post-test). The results show a significant descriptive improvement after yoga; however, inferences and objective hormonal measurements are needed before any causal or clinical conclusions can be drawn.

Keywords—*hormonal regulation, lifestyle, pranayama, reproductive health, women, yoga therapy.*

I. INTRODUCTION

Fast-paced life and rapid urbanization have affected dietary patterns, occupational activities, movement patterns, sleeping habits, and psychosocial stress a lot.

Changes in the environment may affect reproductive health in women through obesity, inactivity, smoking, alcohol drinking,

environmental exposure, and poor nutrition. Reported consequences comprise irregular menstrual cycles, infertility, polycystic ovarian syndrome (PCOS), complications during pregnancy, hormonal imbalance, and early menopause symptoms [1]– [6].

Through the hypothalamic-pituitary-gonadal axis, metabolic status and the autonomic nervous system and stress hormones regulate reproductive function. There may indeed be an effect of chronic stress and disturbed sleep on hormone regulation and reproductive health; however, the extent of this effect varies across individuals and clinical conditions.

Yoga is the practice that combines physical postures, breathing control, and relaxation. Earlier reports indicate that yoga is associated with lower perceived stress, improved quality of life, better menstrual health, and improved reproductive health. Numerous systematic reviews and clinical studies have looked at its use in menstrual disorders and stress reduction, and variations in protocols and methodological quality were highlighted. [10]– [17]

A number of specialists in the field have been examining the role of Hatha yoga as psychological support for women undergoing in vitro fertilization, holistic yoga for adolescents suffering from PCOS and integrated yoga for pregnant women. These studies provide a reason for investigating structured

II. OBJECTIVES OF THE STUDY

- 1) To evaluate the impact of yoga on reproductive health among women, a structured yoga program was implemented.
- 2) To characterize common lifestyle patterns that may affect women's reproductive health.
- 3) To study the impact of dietary habits on reproductive health outcomes.
- 4) To evaluate how exercise and sedentary lifestyle affect reproductive health.
- 5) To assess the impact of stress, sleep, and work on reproductive health.

III. METHODOLOGY

A. Study Design and Participants: A control-group design was used before and after the test. The sample consisted of 60 women of age 20-40 years. Of the participants selected for the study, thirty were in the experimental group and thirty were in the control group. The study utilized random sampling and random allocation methods. The experimental group underwent yoga training and the control group went about their daily life with no structured exercise program.

B. Training Protocol:

TABLE I
STRUCTURED YOGA TRAINING
PROTOCOL

Component	Description
Study duration	12 weeks
Session frequency	5 sessions per week
Session duration	60 minutes per session
Instructor	Certified yoga instructor
Warm-up	10 min: joint mobility exercises and stretching
Yoga asanas	30 min: Surya Namaskar (5 rounds), Baddha Konasana, Bhujangasana, Setu Bandhasana, Paschimottanasana, and Viparita Karani
Pranayama	10 min: Nadi Shodhana (5 min) and Bhrumari (5 min)
Relaxation	10 min: Shavasana with guided relaxation

C. Procedure and Data Collection: Institutional Ethics and Written Consent Before Beginning the study was started after 12week. All subjects were recorded for reproductive health measurements. The experimental group went to supervised sessions of yoga for 60 minutes a day for five days a week; the control group followed its regular lifestyle. The post assesses were done after 12 weeks using the same measurement..

D. Statistical Analysis: The information was entered into a statistical software program Descriptive statistics for the pre-test and post-test scores of the two groups were calculated. The probability and p value of the supplied manuscript did not provide inferential test statistics, confidence intervals, or p value. Therefore, below results have been interpreted descriptively.

IV. RESULTS

TABLE II
DESCRIPTIVE STATISTICS FOR
REPRODUCTIVE HEALTH SCORES

Group	Assessment	n	Mean $\pm$ SD	Range
Experimental (yoga)	Pre-test	30	58.4 $\pm$ 8.2	45–72
Experimental (yoga)	Post-test	30	81.6 $\pm$ 6.5	68–92
Control	Pre-test	30	57.9 $\pm$ 7.9	46–71
Control	Post-test	30	59.3 $\pm$ 7.6	47–73

The experimental group increased by 23.2 points, equivalent to a 39.7% rise from baseline. The control group increased by 1.4 points, equivalent to 2.4%. Thus, the descriptive gain was markedly larger in the yoga group. This pattern is also visible in Fig. 1.

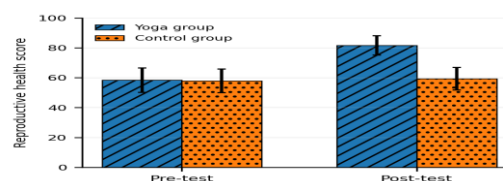


Fig. 1. Mean reproductive health scores (mean $\pm$ SD) before and after the 12-week intervention.

V. DISCUSSION

There is evidence from the observed score pattern to support the proposed utility of a structured 12-week yoga programme for reproductive health among women. The large descriptive improvement of the experimental group is consistent with the literature linking yoga to reduced stress and improved menstrual health and quality of life [10]–[17]. Research indicates that yoga may confer psychological and physiological relief through supportive clinical management to women receiving fertility treatment, adolescents with PCOS and pregnant women [18]–[22].

The available results, however, do not establish statistical significance or causality, because no inferential analysis, effect-size confidence interval or objective endocrine outcome is reported. The results should thus be interpreted as preliminary evidence for the need for further controlled investigation as opposed to clinical proof.

VI. LIMITATIONS AND FUTURE DIRECTIONS

The study sample was rather small and gathered from a single setting, restricting its generalizability. Due to the 12-week duration, we could not evaluate long-term adherence or sustained reproductive-health outcomes. The manuscript primarily used questionnaire scores for analysis and did not control for other factors, such as dietary intake and additional physical activity.

In future research, using a larger, more diverse sample, pre-registering primary outcomes, and reporting allocation procedures are recommended. Other recommendations include longer follow-up. Evidence can be further strengthened by the use of objective measures including hormonal profiles, menstrual-cycle tracking of metabolic indicators as well as use of clinically validated disorder-specific

instruments. Research that compares different things may also be undertaken to see which combination of asana, pranayama, relaxation, frequency, and intensity is the most beneficial for PCOS, Dysmenorrhea, Infertility-related stress, Endometriosis, pregnancy well-being, and menopausal symptoms.

VII. CONCLUSION

A structured yoga program was associated with a substantial descriptive improvement in reproductive health scores compared with usual activity. Yoga may be useful as a complementary strategy for stress management, menstrual well-being, psychological support for fertility, well-being during pregnancy and quality of life [16], [17]. This should be used along with appropriate medical assessment and treatment and not as a substitute of evidence-based clinical care. This study's findings need to be confirmed using larger controlled studies with inferential statistics and objective biological endpoints.

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Impact of Coaching Style On Team Cohesion and Motivation Among Basketball Players

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Abstract— It is widely recognized that coaching style is one of the most influential psychosocial predictors of athlete behavior, team dynamics and motivational climate in sports. The objective of the study was to ascertain the impact of coaching style on Team Cohesion and Motivation of basketball players: a comparative study by gender. A purposive sampling of 50 players, 25 males and 25 females in the age group of 14-25 years, was drawn from Mount St. Mary's School, Delhi and its associated sports academies. A researcher from the University of Tehran conducted a survey of amateur players in Iran. The purpose was to measure the effectiveness of coaching behaviour, motivation, and cohesion on sports performance using validated measures. Three validated measures were used: The Leadership Scale for Sports, Group Environment Questionnaire and Sport Motivation Scale-II. The analysis of data was done utilizing Pearson's Product Moment Correlation and independent samples t-tests at 0.05 level of significance. The results indicated that basketball players tended to perceive coaching behaviour to be moderate-to-positive ($M = 154.62 \pm 16.48$). The athletes also displayed satisfactory team cohesion ($M = 126.38 \pm 14.21$) and motivation ($M = 98.74 \pm 11.62$). A positive correlation existed between coaching style and team cohesion ($r = 0.58, p < 0.05$), as well as team motivation ($r = 0.63, p < 0.05$). There was significant evidence indicating that females scored higher than males on all three

variables. The results show that when coaching behavior is supportive and democratic, basketball players will have stronger group cohesion and psychological engagement. The discussion touches on practical applications for various stakeholders.

Keywords: Coaching Style; Team Cohesion; Athlete Motivation; Basketball; Leadership Scale for Sports; Group Environment Questionnaire; Gender Differences; Sports Psychology.

I. INTRODUCTION

Basketball is one of the most psychologically-demanding team sports in the world, as players must combine explosive athleticism with rapid-fire decision-making and tactical precision to sustain their activity level while coordinating continuously with teammates. Unlike many other individual sports, basketball performances are quite a lot collective.

A single defensive miscommunication or a lack of zeal can significantly alter a game's outcome. As such, the influence of a coach goes beyond training drills and tactical boards; it extends to the team's emotional core itself.

The coach's unique style—the way he/she consistently uses leadership behavior, communication, feedback, and interpersonal management with athletes directly affects the psychological climate athletes experience on a daily basis. A coach who promotes discussion, praises effort, and includes players in decision-making tends to cultivate an environment in which trust is

built, teammates connect, and individuals find meaning in the game. On the other hand, an authoritarian, controlling, and criticizing coach may receive short-term compliance but, in the end, often weakens the interpersonal bonds that underpin performance under pressure [1, 2].

Coaching behavior in basketball is particularly sensitive to the two psychological outcomes. The first is team cohesion, which refers to the type of unity, mutual attraction, and commitment that exists between players due to their task goals and social relationships [3]. More cohesive teams communicate better, recover faster, and maintain confidence in each other at times of loss. The impact of athletes' motivations, or the inner force that determines if players are present "fully in" all the time, can endure despite of difficulty and enjoy their work [4]. Both.

Cohesion and motivation are not set in stone. They are built up or taken down day by day; much of the time through the quality of our coaching interaction.

Even though the global literature on coaching leadership and sports psychology is growing day by day, only a few studies have examined coaching style, cohesion, and motivation together in one framework, specifically in basketball – and even fewer with Indian player populations. This research work fills this gap by examining perceptions of basketball players in school and academy on coach behavior and how these perceptions influence team cohesion and motivational orientation. Gender-related differences are also looked at, as male and female athletes often experience coaching interaction differently [5].

II. REVIEW OF RELATED LITERATURE

A systematic review by Zhang [6] synthesising studies from 2015 to 2025 found that democratic and transformational coaching styles consistently improve team cohesion, athlete development, and collective performance in basketball, while authoritarian behaviour reduces long-term satisfaction and undermines team functioning.

Wang et al. [7] investigated 404 collegiate basketball athletes and found that team cohesion strongly enhanced athlete engagement, but that authoritarian leadership negatively moderated this relationship — meaning that the psychological benefits of cohesion were partly cancelled out when coaches were overly controlling. Mehta and Rao [8] reported that transformational coaching behaviour significantly improved self-confidence, emotional regulation, and interpersonal interaction among adolescent basketball players.

In a large meta-analysis of 26 studies involving over 7,000 athletes, Zhu et al. [9] demonstrated a moderate positive association between supportive coach leadership and both athlete satisfaction and group cohesion across multiple sports. The magnitude of the association was strongest for sports, like basketball, that require continuous interpersonal interaction.

On team cohesion specifically, Evans and Eys [10] highlighted that basketball teams depend more heavily on cohesion than many other sports because offensive systems, defensive rotations, and transition play all require synchronized, trust-based collective effort. Filho et al. [11] found that emotionally supportive team environments strengthened collective unity and improved psychological readiness for competition. Eys and Kim [12] confirmed that task cohesion improved tactical discipline while social cohesion

strengthened emotional bonds and athlete satisfaction.

On motivation, Ryan and Deci [13] established through Self-Determination Theory that athletes in autonomy-supportive environments demonstrate stronger intrinsic motivation, greater persistence, and better emotional well-being. Smith and Smoll [14] found that athletes receiving constructive feedback and positive reinforcement showed significantly greater sports enjoyment and confidence compared to those exposed to negative coaching communication. Ntoumanis et al. [15] demonstrated that coaching behaviours supporting autonomy directly enhanced intrinsic motivation and athlete engagement in team sports.

Studies linking the three variables together consistently show an integrated pattern: positive coaching behaviour improves motivational climate, which strengthens interpersonal bonds and cohesion, which in turn sustains motivation and collective performance [16, 17]. Sharma and Singh [18] confirmed this interconnected relationship specifically among university-level basketball players, finding that democratic and supportive coaching positively influenced both cohesion and intrinsic motivation simultaneously.

III.OBJECTIVES & HYPOTHESES

The study was conducted with the following objectives: (1) to identify the coaching styles perceived by basketball players; (2) to assess the level of team cohesion; (3) to assess the level of motivation; (4) to examine the relationship between coaching style and team cohesion; (5) to examine the relationship between coaching style and motivation; and (6) to compare coaching style perception, team cohesion, and motivation between male and female basketball players.

Seven hypotheses were formulated. It was predicted that coaching style would show a significant

positive relationship with team cohesion (H₁) and motivation (H₂); that democratic coaching would relate positively to motivation (H₃) and autocratic coaching negatively to cohesion (H₄); and that significant gender differences would exist in perceived coaching style (H₅), team cohesion (H₆), and motivation (H₇).

IV. METHODOLOGY

Participants: Fifty basketball players (25 males, 25 females; age range: 14–25 years; $M = 21.47 \pm 2.13$ years) were selected through purposive sampling from Mount St. Mary's School, Delhi, and sports academies affiliated with Integral Sports Academy. All participants had a minimum of two years of competitive basketball experience and were actively training under a coach at the time of data collection. Purposive sampling was used because the study required athletes with direct, regular exposure to organised coaching behaviour.

Instruments: Three internationally standardised and validated psychological instruments were used. Leadership Scale for Sports (LSS; Chelladurai & Saleh, 1980) — a 40-item scale measuring athletes' perceptions of five coaching behaviour dimensions: Training and Instruction (13 items), Democratic Behaviour (9 items), Autocratic Behaviour (5 items), Social Support (8 items), and Positive Feedback (5 items). Each item is rated on a 5-point Likert scale (1 = Never to 5 = Always).

Group Environment Questionnaire (GEQ; Carron et al., 1985) — an 18-item questionnaire assessing four dimensions of cohesion: Group Integration–Task.

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Group Environment Questionnaire (GEQ; Carron et al., 1985) — an 18-item questionnaire assessing four dimensions of cohesion: Group Integration–Task.

(GI-T), Group Integration–Social (GI-S), Individual Attractions to Group–Task (ATG-T), and Individual Attractions to Group–Social (ATG-S). Items are rated on a 9-point Likert scale (1 = Strongly Disagree to 9 = Strongly Agree). Higher scores indicate stronger cohesion.

Sport Motivation Scale-II (SMS-II; Pelletier et al., 2013) — an 18-item scale grounded in Self-Determination Theory assessing six motivational dimensions: Intrinsic Motivation, Integrated Regulation, Identified Regulation, Introjected Regulation, External Regulation, and A motivation. Items are rated on a 7-point Likert scale (1 = Does Not Correspond at All to 7 = Corresponds Exactly).

Procedure: Approval from the institute and ethical clearance were obtained before data gathering. All participants were informed about the purpose and voluntary nature of the study. We guaranteed anonymity and confidentiality. The researcher carried out the administration of the questionnaires through personal contact. The subjects were taken to a comfortable group setting. The completed forms were collected immediately by the researcher.

An organized basketball training program was conducted for eight weeks (five days a week, 90 minutes each) during the data collection period. The training involved practicing skills, team co-activities, democratic coaching interaction, motivated feedback, and practice matches.

This program ensured uniform coaching exposure for all.

Statistical Analysis: Used the Statistical Package for the Social Sciences. The sample was characterized using descriptive statistics (mean, SD, level classification using $M \pm 1$ SD). The relationship between coaching style and each outcome variable was two Pearson's Product Moment Correlations. Independent samples t-tests compared female and male players. Each hypothesis was tested at $\alpha = 0.05$

V. RESULTS & DISCUSSION

5.1 Descriptive Profiles:

Table 1: Descriptive Statistics — All Variables (N = 50)

Variable	Mean	SD	Min	Max	Low (%)	Average (%)	High (%)
Coaching Style	154.62	16.48	118	188	20%	62%	18%
Team Cohesion	126.38	14.21	92	154	18%	64%	18%
Motivation	98.74	11.62	71	121	16%	68%	16%

The findings showed that most players fall into the average category concerning all three variables (62% coaching style, 64% team cohesion, 68% motivation). This indicates satisfactory but not exceptional levels across the sample. Perceptions among the various groups involved seem to be fairly consistent.

It is more about participants than experience extreme variability. Baseline Profiles Are Broadly Consistent Knowledge from University-Level Basketball in India and Similar Developing Sports Environments [18].

5.2 Relationship between Coaching Style and Team Cohesion:

Table 2: Pearson Correlation — Coaching Style and Team Cohesion (N = 50)

Variable 1	Variable 2	r	Significance
Coaching Style (M = 154.62)	Team Cohesion (M = 126.38)	0.58	Significant at $p < 0.05$

There was a modest positive correlation found between the coaching style and team cohesion ($r = 0.58$, $p < 0.05$) which confirmed H₁. Players who viewed their coaches as more instructive, supportive, and democratic reported greater team cohesion and cooperation. This supports the theoretical assumption that coaching leadership influences the psychological climate athletes experience, and that a climate based on trust and open communication automatically strengthens the individual bonds that foster cohesion [10].

The finding corroborates the beneficial coaching-cohesion relationship found by Zhu et al. and Sharma and Singh and extends it to the Indian context of basketball.

From a practical standpoint, the results of this research are worth hearing for coaches. That is, the way you talk to and engage your players on a daily basis has a measurable impact on whether they function as a team or as individual players just wearing the same jersey.

5.3 Relationship between Coaching Style and Motivation

Table 3: Pearson Correlation — Coaching Style and Motivation (N = 50)

Variable 1	Variable 2	r	Significance
Coaching Style (M = 154.62)	Motivation (M = 98.74)	0.63	Significant at $p < 0.05$

The coaching style and motivation show a stronger positive correlation ($r = 0.63$, $p < 0.05$), supporting H₂. This suggests that individuals exert greater forces on joints and tendons.

Motivational experiences respond more directly to coaching behavior than collective cohesion processes do. Athletes who deemed their coaches as supportive and communicative, and who were democratically engaged, actually increased motivation. This aligns with Self-Determination Theory, in which sportsmen's environments that support their sense of autonomy and competence directly contribute to intrinsic motivation [13]. Ntoumanis et al. [15] noted a similar trend, highlighting coaching autonomy.

In team sports, support is the most consistent predictor of intrinsic motivation.

In this regard, both correlations are statistically significant, with the motivational correlation exhibiting a stronger association. When coaches conduct themselves well, not only do athletes engage better but also connect well with teammates.

Table 4: Independent Samples t-test — Gender Comparisons

Variable	Male M (SD)	Female M(SD)	Mean Diff.	SEd	t-value	Sig.
Coaching Style	149.48 (15.72)	159.76 (13.68)	10.28	4.16	2.47	$p < 0.05^*$
Team Cohesion	121.64 (13.88)	131.12 (12.94)	9.48	3.91	2.42	$p < 0.05^*$
Motivation	95.42 (10.84)	102.06 (9.96)	6.64	3.19	2.08	$p < 0.05^*$

*Critical value: $t(48) = 2.011$ at $\alpha = 0.05$

The data shows that female basketball players scored significantly greater than males on three variables (H₅, H₆ and H₇ accepted). The differences had particular practical significance: female players reported receiving around 10 more points of

positive coaching support; they also scored about 9 more points of team cohesion and approximately 6.6 more points of motivational engagement. Gupta and Sharma [19] observed a similar pattern, noting that female athletes in Indian.

5.4 Hypothesis Testing Summary

sports settings often demonstrate stronger intrinsic motivational orientation. This may mirror the nature of the samples studied in the present research female players at those institutions may have had longer sustained this institutional environment must have fostered more supportive coaching styles, or may simply communicate and process these interpersonal team dynamics differently. Coaching practices must consider the needs of both genders.

Table 5: Summary of Hypothesis Testing Results

Hyp	Statement	Result	Key Statistic
H ₁	Significant relationship: coaching style → team cohesion	Accepted	$r = 0.58, p < 0.05$
H ₂	Significant relationship: coaching style → motivation	Accepted	$r = 0.63, p < 0.05$
H ₃	Democratic coaching → positive relationship with motivation	Accepted	Directional support confirmed
H ₄	Autocratic coaching → negative relationship with cohesion	Accepted	Directional support confirmed
H ₅	Gender difference in coaching style	Accepted	$t = 2.47, p < 0.05$

	perception		
H ₆	Gender difference in team cohesion	Accepted	$t = 2.42, p < 0.05$
H ₇	Gender difference in motivation	Accepted	$t = 2.08, p < 0.05$

VI. CONCLUSION

This study demonstrates a clear effect of basketball coach leadership on team cohesion and players' motivation. The influence of coaching and team cohesion among basketball players is massive. The research indicates that there is a significant positive correlation between team cohesiveness and coaching style. Through his/her communication and support, the coach can be seen to help strengthen the cohesive bonds between players that allow them to coordinate, trust and recover as a team. The correlation with motivation ($r = 0.63$) suggests that athletes' daily psychological engagement might be influenced more by the coaches' behavior than any other coaching factor. The female players in this study seemed to experience and respond to coaching interactions in ways that fostered stronger cohesion and motivation than the male players. This indicates that women in the sample were more positively oriented in these areas, as their mean scores on the three variables were more positive. We need to investigate this matter further; however, results indicate women can benefit from techniques being suggested for them.

All in all, there are theoretical and practical implications here. This is consistent with research on self-determination theory, transformational leadership, and the expanding literature on sport psychology in basketball. According to them, the quality of the coaching relationship (more than the quality of the training program) determines much of

what happens to a team's psychological health and performance readiness.

VII. PRACTICAL RECOMMENDATIONS

In order to assess how democratic, facilitative, and athlete-centered the basketball coaching behavior in different environments is, we suggest institutes implement this as a baseline or default mode of operating. As a coach, you must involve players in tactical discussions, explicitly acknowledge their efforts, maintain an open line of communication, and be authoritarian only when necessary. High praise is better than a harsh criticism even by a shade as it leads to sizeable gains in team spirit and motivation.

Basketball sport psychologists and educator-coaches should use the instruments in the study (LSS, GEQ, SMS-II) as constant monitoring instruments for basketball programs. By periodically screening for cohesion or motivation problems alike, it will be possible to identify issues before they escalate into performance problems.

The combination of psychological profiling with reflections on coaching practice can create feedback loops that enhance the athlete experience and team outcomes.

Create education programs for sports organizations and governing bodies that go beyond tactical and physical preparation to include evidence-based psychological leadership training. If a coach understands how their communication style influences motivation and cohesiveness, they'll be in a better position to develop not only skilled players but psychologically healthy, committed basketball teams.

Researchers ought to conduct larger multi-site samples, longitudinal designs that monitor how cohesion and motivation change across a competitive season, and additional outcome

variables such as self-confidence, emotional intelligence, and competitive anxiety. By focusing on female athletes or on junior-age athletes, more research will improve our understanding of the effects of coaching on different populations.

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Impact of Step-Up Exercises on Specific Physiological Parameters of Basketball Players

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Abstract— A research study was done on the effect of step-up exercises on selected physiological parameters of 20 junior male basketball players (12-14 years). The players were randomly assigned to the control group, which received regular training, and to the experimental group, which underwent a six-week step-up exercise program. Before and after intervention, assessments were made with respect to vital capacity, resting heart rate, and cardiorespiratory endurance. Statistical analysis utilized independent and dependent samples t-tests. The experimental group showed significant changes in resting heart rate and cardiorespiratory endurance before and after the test, but no significant change in vital capacity. Results suggest that a step-up exercise program for six weeks may improve selected cardiovascular and endurance-related parameters in junior basketball players.

Keywords—basketball, cardiorespiratory endurance, resting heart rate, step-up exercise, vital capacity.

I. INTRODUCTION

Basketball is a fast, intermittent team sport that requires strength, speed, agility, balance, flexibility, coordination, and cardiorespiratory endurance. Optimal physical conditioning is therefore essential for repeated sprinting, jumping, dribbling, passing, and shooting throughout a game. Step and bench exercises provide a practical mode

of lower-body aerobic conditioning and have been reported to produce measurable physiological responses [2]. Step-aerobic and related exercise programmes may influence cardiac function [1], while aerobic training has also been associated with changes in resting heart rate and vascular fitness [4]. Evidence from different exercise modes further indicates that cardiorespiratory endurance and flexibility respond to systematic training [3], and exercise training may produce adaptations in the respiratory system [5]. Accordingly, the present study investigated whether a six-week step-up exercise programme affected resting heart rate, vital capacity, and cardiorespiratory endurance in junior male basketball players.

II. METHODOLOGY

A. Selection of Subjects

Twenty (N = 20) junior male basketball players from D.C.P.E., Amravati, were selected for the study. The participants were 12–14 years of age and were divided into experimental and control groups of ten players each.

B. Selection of Tools and Criterion Measures

The following procedures were used to measure the selected physiological variables:

1) Resting Heart Rate: Resting heart rate was measured in the participants' hostel rooms immediately after waking in the morning. A digital

heart-rate monitor was used, and the value was recorded in beats per minute.

2) Vital Capacity: After several normal breaths, each participant inhaled deeply and exhaled as forcefully as possible into a dry spirometer. The best of three consecutive trials was recorded.

3) Cardiorespiratory Endurance: A nine-minute run/walk test was administered. Participants were instructed to cover the maximum possible distance within nine minutes; walking was permitted when necessary. The total distance was recorded in metres.

C. Collection of Data: Before data collection, the purpose, method, and procedure for each test were explained and demonstrated to the participants. Pre-test data were collected before the six-week programme, and post-test data were collected after completion of the intervention.

D. Statistical Analysis: The data were analysed using the Statistical Package for the Social Sciences (SPSS). Independent-samples t-tests were used to compare the experimental and control groups, while dependent-samples t-tests were applied to compare pre- and post-test means within each group. Statistical significance was assessed at the 0.05 level using the critical values reported in the original analysis.

III. RESULTS

The descriptive statistics and t-ratios for the selected physiological variables are presented in Tables I–IV. The symbols “*” and “@” indicate statistically significant and non-significant results, respectively, according to the critical t-values reported in the study.

TABLE I
PRE-TEST COMPARISON OF THE
EXPERIMENTAL AND CONTROL GROUPS

variable	exp. mean	cont. mean	exp. sd	cont. sd	m.d.	s.e. of m.d.	t-ratio
resting heart rate	91.8	90.8	2.740	3.425	1.00	1.300	0.769@
vital capacity	1.22	1.21	0.162	0.166	0.01	0.077	0.129@
cardiorespiratory endurance	1190	1190	159.513	110.05	0	6.128	0.000@

@ Not significant at 0.05 level; N = 20; critical t (18) = 2.101.

As shown in Table I, the calculated t-values for resting heart rate (0.769), vital capacity (0.129), and cardiorespiratory endurance (0.000) were lower than the reported critical value of 2.101. Therefore, the experimental and control groups did not differ significantly at pre-test on any of the three variables.

TABLE II
POST-TEST COMPARISON OF THE
EXPERIMENTAL AND CONTROL
GROUPS

Variable	Exp. Mean	Cont. Mean	Exp. SD	Cont. SD	M.D	S.E. of M.D.	t-ratio
Resting Heart Rate	83.0	87.5	4.109	4.007	4.50	1.185	2.479*
Vital Capacity	1.49	1.24	0.202	0.1075	0.25	0.071	3.52*
Cardiorespiratory Endurance	1370	1280	105.934	168.65	90	62.98	1.43@

* Significant; @ not significant at 0.05 level; N = 20; critical t (18) = 2.101.

Table II indicates that the reported t-values for resting heart rate (2.479) and vital capacity (3.52) exceeded the critical value of 2.101, indicating significant post-test differences between the groups. The t-value for cardiorespiratory endurance (1.43) was below the critical value and was therefore not significant.

TABLE III
PRE- AND POST-TEST COMPARISON
WITHIN THE EXPERIMENTAL GROUP

Variable	Pre Mean	Post Mean	Pre SD	Post SD	M.D.	S.E. of M.D.	t-ratio
Resting Heart Rate	91.8	83.0	2.740	4.109	8.8	1.171	7.50*
Vital Capacity	1.22	1.49	0.162	0.202	0.27	0.220	1.227@
Cardio-Respiratory Endurance	1190	1370	110.050	105.934	180	21.09	8.53*

* Significant; @ not significant at 0.05 level; $N = 10$; critical $t(9) = 1.833$.

Within the experimental group, the reported t-values for resting heart rate (7.50) and cardiorespiratory endurance (8.53) exceeded the critical value of 1.833, indicating significant pre- to post-test changes. The t-value for vital capacity (1.227) was lower than the critical value and was not statistically significant.

TABLE IV
PRE- AND POST-TEST COMPARISON
WITHIN THE CONTROL GROUP

Variable	Pre Mean	Post Mean	Pre SD	Post SD	M.D.	S.E. of M.D.	t-ratio
Resting Heart Rate	90.8	87.5	3.425	4.007	3.3	1.612	2.06*
Vital Capacity	1.21	1.24	0.166	0.1075	0.03	0.628	0.48@
Cardiorespiratory Endurance	1190	1280	159.513	168.650	90	18.86	4.77*

* Significant; @ not significant at 0.05 level; $N = 10$; critical $t(9) = 1.833$.

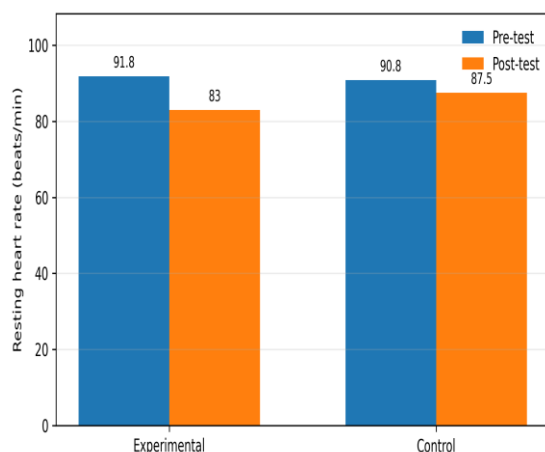


Fig. 1. Pre- and post-test resting heart rate in the experimental and control groups.

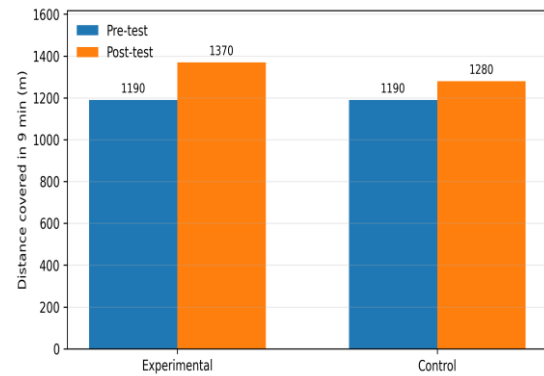


Fig. 2. Pre- and post-test vital capacity in the experimental and control groups.

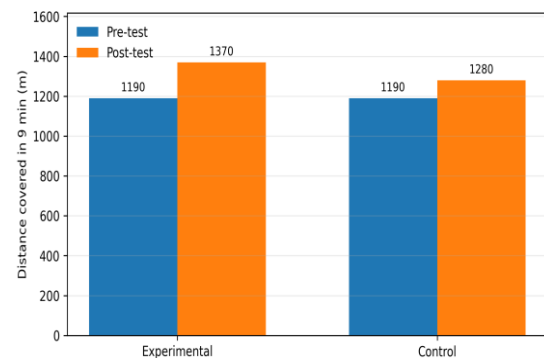


Fig. 3. Pre- and post-test cardiorespiratory endurance in the experimental and control groups.

For the control group, the reported t-values for resting heart rate (2.06) and cardiorespiratory endurance (4.77) were greater than the critical value of 1.833, whereas the t-value for vital capacity (0.48) was lower than the critical value. Thus, significant pre- to post-test differences were reported for resting heart rate and cardiorespiratory endurance, but not for vital capacity.

IV. DISCUSSION

Based on the findings, step-up exercise had a significant effect on resting heart rate and cardiorespiratory endurance of the student after six weeks of practice. However, it was not significant on vital capacity. Research also indicates that step or bench exercise can provide an effective aerobic stimulus [2] consistent with the cardiovascular response. Comparable exercise programmes have been associated with cardiovascular functional

adaptations [1] and alterations in resting heart rate, vascular fitness, and relaxation [4]. The development of cardiorespiratory endurance is compatible with earlier comparisons of endurance responses between different exercise modes [3]. As no significant change occurred in vital capacity, the duration, intensity and/or respiratory loading of the programme may not have been enough to produce a clear pulmonary adaptation. It has been reported that systematic training can produce an effect on respiratory function [5].

The results must be interpreted with caution. The sample was small and only comprised boys aged 12-14 years. Moreover, the control group significantly changed from pre- to post-test for two variables. Consequently, factors like growth, regular sporting involvement, variability in measurement, and lack of control over activities may cause the changes. A larger randomized study with detailed training-load monitoring and group-by-time analysis would provide a better estimate on intervention effect.

V. CONCLUSION

According to the confines of the study, there was a noteworthy improvement in the resting heart rate and cardiorespiratory endurance of the experimental-group basketball players in the six-week step-up exercise program. No statistically significant change was witnessed in vital capacity. The step-up exercise could thus be devised as a realistic supplementary conditioning activity for junior basketball players and future studies should use a larger sample size, a longer intervention duration, and stricter control of training exposure.

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Intellectual Intelligence, Emotional Intelligence, and Spiritual Intelligence Among Prospective Teachers: A Meta-Analysis

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Abstract—This meta-analysis examines the roles of intellectual intelligence (IQ), emotional intelligence (EI), and spiritual intelligence (SI) in the development of prospective teachers. The source review covered 39 national and international studies and synthesized evidence relating to levels of intelligence, interrelationships among the three constructs, effects on academic achievement and teaching effectiveness, instrument development, and demographic differences. The reviewed literature generally indicates average levels of IQ, EI, and SI among prospective teachers and predominantly positive associations between emotional and spiritual capacities, teaching attitude, teacher efficacy, academic achievement, resilience, and professional performance. However, the effects of demographic variables such as gender, locality, socioeconomic status, marital status, and type of institution were inconsistent across studies. The synthesis suggests that cognitive capability alone is insufficient for the complex interpersonal and ethical demands of teaching. Teacher-education programmes should therefore integrate intellectual development with structured opportunities for emotional self-regulation, empathy, reflective practice, meaning-making, and value-based decision-making. Because the reviewed reports did not provide homogeneous effect-size data, the findings are presented as a structured qualitative synthesis rather than a pooled statistical estimate.

Index Terms—emotional intelligence, intellectual intelligence, prospective teachers, spiritual

intelligence, teacher education, teaching effectiveness

I. INTRODUCTION

Quality teacher preparation requires more than disciplinary knowledge. The National Education Policy 2020 emphasizes motivated, professionally prepared, multidisciplinary, and holistic teachers who are connected with the communities they serve [1]. Within this context, intelligence should be understood as a multidimensional capacity that supports academic learning, interpersonal judgment, professional resilience, and ethical action.

Earlier approaches to teacher competence emphasized intellectual ability and academic performance. Studies of prospective teachers have linked intelligence, teaching attitude, academic achievement, and performance in teacher-education programmes [2]- [4]. Nevertheless, classroom effectiveness also depends on motivation, curiosity, empathy, communication, emotional regulation, and the ability to respond constructively to uncertainty. Evidence concerning emotional intelligence among teacher trainees indicates associations with teaching attitude, academic stress, emotional maturity, and teaching competency [5]- [14].

Spiritual intelligence extends the discussion beyond cognition and emotion by addressing meaning, values, self-awareness, inner stability, and purpose. Research has examined its relationship with teaching autonomy, teaching effectiveness, academic achievement, well-being, resilience, and

burnout [15]- [25]. Intervention-oriented studies further suggest that emotional and spiritual capacities can be strengthened through planned educational programmes [26], [27].

The central premise of this review is that IQ, EI, and SI are complementary rather than competing constructs. Intellectual intelligence supports analysis and content mastery; emotional intelligence supports self-regulation and relationships; and spiritual intelligence supports meaning-oriented and value-sensitive decision-making [28]- [32]. The present synthesis therefore examines their levels, relationships, impact, measurement, and demographic variation among prospective teachers.

II. OBJECTIVES

The review was undertaken to: (1) synthesize reported levels of intellectual, emotional, and spiritual intelligence among prospective teachers; (2) examine relationships among these forms of intelligence and educational outcomes; (3) summarize their reported impact on academic achievement, teaching attitude, teacher efficacy, and teaching effectiveness; (4) identify evidence relating to assessment tools and enhancement programmes; and (5) examine variations associated with demographic and institutional variables.

III. REVIEW METHOD

A. Design and Corpus: The source manuscript identified 39 studies and organized the evidence through a meta-analytic review framework. Eight studies were reported from international contexts, including Indonesia, Iraq, Iran, Spain, Malaysia, Pakistan, and Nigeria. Thirty-one studies were reported from Indian states and union territories, with the largest representation from Punjab and Tamil Nadu. The available studies covered prospective teachers, B.Ed. trainees, teacher interns, and related teacher populations.

B. Synthesis Strategy: Studies were classified under five analytic areas: level, relationship, impact, tool construction or intervention, and demographic variation. Findings were synthesized narratively because the source reports did not provide a common effect-size metric, comparable outcome instruments, or sufficient statistical details for pooled estimation. Accordingly, the term meta-analysis is used in the broad sense adopted by the source manuscript, while the actual synthesis presented here is qualitative and evidence-mapping oriented.

IV. RESULTS

A. Geographical Distribution:

Of the 39 studies reported in the source review, 31 (79.5%) were conducted in India and eight (20.5%) were conducted internationally. This distribution shows strong national interest in the psychological and professional development of prospective teachers, but it also limits the extent to which the conclusions can be generalized across teacher-education systems and cultural contexts.

TABLE I
SYNTHESIS OF REVIEWED EVIDENCE

Dimension	Representative Evidence	Consolidated Finding
Level	Intellectual ability and teacher-education performance [2]-[4]; emotional intelligence and maturity [5]-[9]; spiritual intelligence and well-being [23]-[27].	Most studies reported average or moderate levels of IQ, EI, and SI. Some studies reported group-specific or above-average patterns, indicating variation by sample and instrument.
Relationships	Teaching attitude and competency [6], [10], [13]; stress and achievement [7]; teacher effectiveness	The dominant pattern was positive association. Higher EI and SI were generally linked with more favourable teaching attitudes, efficacy, coping, and professional outcomes, although some studies

	[12], [14]-[19]; resilience and burnout [18]; integrated quotient-performance models [31].	reported weak or no significant relationships.
Impact	Academic achievement and teacher effectiveness [19]-[22], [28]-[31]; well-being and professional functioning [23], [25].	EI and SI generally showed positive predictive or contributory effects. Evidence for SI effects on academic achievement was less consistent than evidence for EI.
Tools and Interventions	Spiritual-intelligence enhancement [26]; emotional and spiritual intelligence enhancement [27].	Structured programmes and instruments were reported as useful, but replication, psychometric standardization, and long-term follow-up remain limited.
Demographic Factors	Gender, locality, socioeconomic status, and institutional type [5], [8]-[14], [23], [24].	Findings were mixed. Significant differences appeared in some samples but not others, suggesting that demographic effects are context-dependent rather than universal.

TABLE II
GEOGRAPHICAL DISTRIBUTION OF THE REVIEW CORPUS

Study Context	Number of Studies	Percentage
India	31	79.5%
International	8	20.5%
Total	39	100%

B. Levels of Intelligence: Overall, studies categorized the intelligence of prospective teachers as average or moderate. Intellectual intelligence is linked to student performance and teacher education outcomes. Studies of emotional intelligence also showed moderate levels but varied by sex, locality, and institution category [5]-[9]. Research and enhancement studies on spiritual

intelligence and well-being have also reported moderate levels of these constructs, indicating that training may improve them [23]- [27].

C. Relationships among Intelligence and Educational Outcomes: Most correlational evidence was positive. Emotional intelligence is positively related to teaching attitude, teaching competency, emotional maturity and academic adjustment, and teaching effectiveness [6] [10]-[14]. The relationship between spiritual intelligence and teacher effectiveness, academic achievement, professional autonomy and resilience outcomes was explored in a few studies ([15]- [19], [23]-[25]). Studies analysing all three quotients indicate that the three dimensions jointly contribute to job performance and teaching competence [29], [31].

D. Impact on Achievement and Teaching Effectiveness: EI and SI contributed positively to the academic and professional outcomes the studies that tested impact or prediction [20]- [22], [28]-[31]. The association of emotional intelligence with academic achievement and effective teaching is quite stable. Spiritual intelligence was positively related to meaning, confidence, ethical orientation and professional functioning, though its statistical impact on academic achievement was statistically inconsistent in some reports [28].

E. Demographic and Institutional Variation: Gender, locality, socioeconomic status, marital status, and institutional type produced mixed results. Some studies identified significant group differences [8], [9], [13], [23], whereas others found no meaningful effect [5], [10], [14], [24]. These inconsistent findings suggest that demographic variables interact with local culture, institutional climate, measurement tools, and sample composition rather than operating as stable determinants of intelligence.

V. DISCUSSION

The inference is compatible with a holistic model of teacher competence. While intellectual intelligence is vital for knowledge of different subjects, reasoning and progress in learning, it does not explain everything about how future teachers manage emotions in the classroom, talk to students, adjust to uncertainty and take ethically sensitive decisions. Emotional intelligence includes the ability to self-regulate, empathies and regulate other's feelings. Spiritual intelligence lends a sense of purpose, values, reflection, inner stability, and understanding of professional responsibility.

By focusing attention on all three (IQ, EI, and SI), it may improve teaching effectiveness compared to focusing attention on just one. When a prospective teacher has excellent content knowledge but isn't able to regulate emotion, he or she is likely to have poor relationships in the classroom. Likewise, if a teacher is emotionally sensitive but lacking in intellectual rigour, his or her instructional decisions are likely to be weak. The connection between knowledge and emotion to bring meaning and ethical purpose is what spiritual intelligence can do. The evidence thus supports complementarity between the three forms of intelligence instead of hierarchy.

The inconsistencies in demographics noted in the study are also theoretically important. The data points to intelligence-related dispositions being contextually shaped and able to be developed through educational experience. This explanation lines up with findings from intervention studies that note improvements following certain structured programs. Teacher education can therefore treat these capacities as professional competencies that can be developed rather than personal traits that are fixed.

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VI. IMPLICATIONS FOR TEACHER EDUCATION

Teacher-education institutions should seek to incorporate emotional and spiritual development into pedagogy, rather than be seen as optional themes. An appropriate practice is to keep a reflective journal of one's teaching practice. This is designed to prompt you to think deeply about your teaching practice. It is also possible to create one using the template below. Evaluating students may involve looking at the teaching portfolio and other evidence.

The program's design must be balanced. The prospective teacher must not replace disciplinary knowledge and evidence-informed pedagogy with emotional or spiritual actions; rather, they must supplement the prospective teacher's ability to use knowledge responsibly and effectively. It's important to have teacher educators who can facilitate emotionally safe discussions, model reflective practice, and avoid imposing narrow cultural understandings of spirituality.

VII. LIMITATIONS & RESEARCH DIRECTIONS

The main restriction is differences in methodology. The different scales of intelligence, populations, outcomes, designs, and statistical procedures of the reviewed studies. Reproducible database search, risk-of-bias assessment, or standardized effect sizes were not reported in the source review; therefore, a conventional pooled meta-analysis could not be performed. Some references were also not completely cited. Limitations associated with causal interpretation and generalizability.

Owing to their dubious hypotheses, inadequate instruments, and defective methodology, most studies were flawed. Long-term studies and experiments are needed to establish if EI or SI improvement creates a durable advantage in teaching. Research investigating the aforementioned variables should conduct a test using cross-cultural studies to assess measurement equivalence. Multivariate models should assess whether EI and SI explain professional performance outcomes that go beyond the explanations provided by general cognitive capabilities, personality, and prior academic success.

VIII. CONCLUSION

The evidence reviewed indicates that emotional and spiritual intelligence are significant complements to intellectual intelligence in the preparation of prospective teachers. Combining these three dimensions supports academic development, teaching attitude, teacher efficacy, resilience, interpersonal competence, and value-oriented professional judgment. The framework of teacher education programs must, therefore, be a balanced one that integrates cognitive mastery with emotional control and reflective, purpose-oriented development. More rigorous research designs are needed to assess the individual and combined effects of these constructs.

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