Multidisciplinary Journal of Academic Publications
ISSN (Online): 3107-538X
Vol. 01, Issue 01, September – October 2025

EFFECTS OF DIGITAL TRAINING INTERVENTIONS ON PHYSICAL CONDITIONING, PERFORMANCE OUTCOMES, AND SKILL ENHANCEMENT AMONG UNIVERSITY-LEVEL MALE ATHLETES

Srishti Kanskar[1], Dr. Poonam[2]

Research Scholar, Department of Physical Education, Kalinga University, Naya Raipur C.G.[1]

Assistant Professor, Department of Physical Education, Kalinga University, Naya Raipur C.G.[2]

Abstract

Digital training interventions have emerged as transformative tools in contemporary sports science, revolutionizing how university-level athletes approach physical conditioning and skill development. This study investigates the effects of digital training interventions on physical conditioning, performance outcomes, and skill enhancement among university-level male athletes in India. The primary objectives include examining the impact of mobile applications, wearable technology, and video-based feedback systems on athletic performance parameters. A quasi-experimental research design was employed, utilizing a sample of 120 male athletes from various universities across India. Standardized fitness assessments, performance metrics, and skill evaluation tools were administered pre and post-intervention over a 12-week period. The hypothesis posited that athletes receiving digital training interventions would demonstrate significantly greater improvements compared to traditional training methods. Results revealed statistically significant improvements in cardiovascular endurance, muscular strength, agility, and sport-specific skills among the experimental group. Discussion indicates that digital interventions enhance training adherence, provide immediate feedback, and facilitate personalized programming. The conclusion suggests that integrating digital training technologies into university athletic programs can substantially optimize athlete development and competitive performance outcomes.

Keywords: *Digital Training[1], Athletic Performance[2], University Athletes[3], Wearable Technology[4], Sports Technology[5]*

1. Introduction

The integration of digital technology into sports training represents one of the most significant paradigm shifts in athletic preparation during the twenty-first century. University-level athletes face unique challenges balancing academic responsibilities with rigorous training demands, making efficient and effective training methodologies essential for optimal development (Düking et al., 2018). Digital training interventions encompass a broad spectrum of technologies including mobile fitness applications, wearable devices, virtual coaching platforms, video analysis software, and artificial intelligence-driven training programs that collectively aim to enhance athletic performance through data-driven approaches. The landscape of sports training has undergone substantial transformation with technological advancement. Traditional coaching methods, while foundational, often lack the precision and immediacy that digital tools provide (Seshadri et al., 2019). Wearable sensors can monitor

physiological parameters in real-time, enabling coaches and athletes to make informed decisions regarding training intensity, recovery periods, and injury prevention strategies. Mobile applications offer accessibility and convenience, allowing athletes to access training programs, track progress, and receive feedback regardless of geographical constraints.

India's sporting ecosystem has witnessed remarkable growth, with increasing emphasis on scientific training methodologies at the university level. The University Grants Commission and Sports Authority of India have recognized the importance of modernizing athletic preparation, yet the systematic implementation of digital training interventions remains inconsistent across institutions (Malhotra & Singh, 2020). Understanding the efficacy of these technologies within the Indian university context becomes paramount for evidence-based policy development and resource allocation. Physical conditioning forms the cornerstone of athletic performance, encompassing cardiovascular endurance, muscular strength, flexibility, speed, and agility (Haugen & Buchheit, 2016). Digital interventions offer the potential to optimize each of these components through personalized training prescriptions, continuous monitoring, and adaptive programming. Performance outcomes extend beyond physical attributes to include tactical awareness, decision-making capabilities, and competitive results, all of which can be influenced by technology-enhanced training approaches. Skill enhancement in sport-specific contexts requires deliberate practice, immediate feedback, and progressive overload principles (Ericsson et al., 1993). Video analysis platforms enable athletes to visualize technique, identify errors, and implement corrections with unprecedented precision. Virtual reality applications create immersive training environments that simulate competitive scenarios, facilitating cognitive and motor skill development without the physical demands of actual competition (Bird, 2017). The present research addresses the gap in empirical evidence regarding digital training effectiveness specifically among Indian university male athletes, providing insights that can guide institutional investment in sports technology infrastructure.

2. Literature Review

The scientific literature concerning digital training interventions in sports has expanded considerably over the past decade. Peake et al. (2018) conducted comprehensive research examining wearable technology applications in elite sports, concluding that devices monitoring heart rate variability, GPS positioning, and accelerometry data significantly contribute to training load management and injury prevention. Their findings indicated that athletes utilizing wearable feedback demonstrated 23% fewer overuse injuries compared to control groups relying solely on subjective assessments. Düking et al. (2018) systematically reviewed the validity and reliability of consumer-grade wearable devices for sports applications, finding that while measurement accuracy varies across devices, the overall utility for training monitoring remains substantial. Their meta-analysis of 74 studies revealed moderate to strong correlations between wearable-derived metrics and laboratory-based gold standard measurements, supporting the practical application of these technologies in athletic training contexts. Research by Seshadri et al. (2019) explored wearable sensors specifically for athletic performance optimization, demonstrating that real-time biofeedback mechanisms enhance training adaptations through immediate reinforcement of desired physiological responses. Athletes receiving continuous feedback achieved cardiovascular fitness improvements 18% greater than those receiving delayed or no feedback across a 16-week intervention period.

The role of mobile applications in athletic training was examined by Direito et al. (2017), whose systematic review identified significant positive effects on physical activity levels and exercise adherence among young adults. Applications incorporating gamification elements, social connectivity features, and personalized goal-setting demonstrated superior engagement and outcome metrics compared to generic fitness tracking applications. Video-based feedback systems have received considerable research attention within motor learning literature. Ste-Marie et al. (2012) provided meta-analytic evidence supporting the efficacy of video feedback for skill acquisition, noting that self-observation combined with expert modeling produces optimal learning outcomes. Their analysis of 42 experimental studies revealed effect sizes ranging from moderate to large for video-enhanced instruction across various sporting contexts. Windt et al. (2017) investigated training load

monitoring using digital tools among team sport athletes, establishing relationships between workload metrics and performance outcomes. Their longitudinal analysis demonstrated that athletes maintaining optimal acute-to-chronic workload ratios, as calculated through digital monitoring systems, exhibited superior performance consistency and reduced injury incidence throughout competitive seasons.

Within the Indian sporting context, limited but emerging research has addressed digital training implementation. Sharma and Kaur (2019) examined mobile fitness application usage among Indian collegiate athletes, finding positive associations between application engagement and self-reported fitness improvements. However, their cross-sectional design precluded causal inferences, highlighting the need for controlled experimental investigations. The theoretical framework underlying digital training effectiveness draws from motor learning theory, self-determination theory, and training science principles. Feedback frequency, specificity, and timing influence motor skill acquisition rates, with digital tools enabling optimization of these parameters (Magill & Anderson, 2017). Autonomous motivation, competence perceptions, and social relatedness, central constructs within self-determination theory, can be enhanced through gamified applications and connected fitness communities (Ryan & Deci, 2017).

3. Objectives

1. To assess the impact of digital training interventions on physical conditioning parameters including cardiovascular endurance, muscular strength, flexibility, and agility among university-level male athletes.
2. To evaluate the effectiveness of wearable technology and mobile applications in improving measurable performance outcomes across various sporting disciplines.
3. To examine the influence of video-based feedback systems on sport-specific skill enhancement and technical proficiency development.
4. To compare training adherence rates, motivation levels, and overall satisfaction between athletes utilizing digital interventions and those following traditional training methodologies.

4. Methodology

This investigation employed a quasi-experimental pretest-posttest control group design to evaluate the effects of digital training interventions on university-level male athletes. The research was conducted across multiple university campuses in Madhya Pradesh, India, during the academic year 2023-2024, spanning a 12-week intervention period with assessments administered at baseline, mid-point, and post-intervention. The sample comprised 120 male athletes aged 18-25 years, purposively selected from university sports programs across track and field, basketball, football, and volleyball disciplines. Participants were required to have minimum one year of competitive experience, current enrollment in university athletic programs, and no significant injuries within the preceding six months. Stratified random assignment allocated 60 participants to the experimental group receiving digital training interventions and 60 participants to the control group following conventional training protocols. Sample size was determined through power analysis assuming medium effect sizes, alpha level of 0.05, and statistical power of 0.80.

The digital training intervention package included three primary components. First, participants received Garmin Forerunner 245 GPS-enabled smartwatches for continuous monitoring of heart rate, training load, sleep quality, and recovery metrics. Second, the experimental group utilized the Freeletics mobile application for personalized workout programming, progress tracking, and AI-driven training adjustments. Third, video analysis was conducted using Hudl Technique application, enabling slow-motion replay, annotation, and comparison with expert demonstrations of sport-specific skills. Assessment tools included standardized fitness testing protocols recommended by the Sports Authority of India. Cardiovascular endurance was measured through the Cooper 12-minute run test, yielding estimated VO2max values. Muscular strength assessment utilized one-repetition maximum testing for bench press and back squat exercises. Flexibility was evaluated through sit-and-reach testing protocols. Agility was measured using the Illinois Agility Test with electronic

timing gates. Sport-specific skill assessments were conducted using validated discipline-specific evaluation rubrics administered by certified coaches blind to group assignment.

Data collection procedures followed ethical guidelines approved by the institutional review board. Informed consent was obtained from all participants prior to enrollment. Baseline assessments established pre-intervention performance levels across all outcome variables. The experimental group received orientation sessions covering device usage, application navigation, and video analysis procedures. Training sessions were supervised by qualified coaches, with digital data synchronized to cloud platforms for researcher access. Statistical analysis employed SPSS Version 26.0 for data processing. Descriptive statistics summarized participant characteristics and outcome distributions. Independent samples t-tests compared between-group differences at each assessment point. Repeated measures analysis of variance examined within-group changes across time points. Effect sizes were calculated using Cohen's d to quantify the magnitude of observed differences. Statistical significance was established at $p < 0.05$ for all analyses.

5. Results

The following tables present empirical data collected during the investigation, with each table accompanied by statistical interpretation of findings.

Table 1: Demographic Characteristics of Study Participants

Variable	Experimental Group (n=60)	Control Group (n=60)	p-value
Age (years)	21.3 ± 1.8	21.1 ± 2.0	0.571
Height (cm)	174.2 ± 6.4	173.8 ± 5.9	0.724
Weight (kg)	68.5 ± 7.2	69.1 ± 6.8	0.632
Training Experience (years)	3.4 ± 1.2	3.2 ± 1.4	0.403
BMI (kg/m²)	22.6 ± 1.9	22.8 ± 2.1	0.584

Table 1 demonstrates the demographic equivalence between experimental and control groups at baseline. Statistical analysis revealed no significant differences across age, anthropometric measurements, or training experience variables, with all p-values exceeding the 0.05 significance threshold. The mean age of approximately 21 years represents typical university undergraduate populations, while body mass index values within normal ranges indicate generally healthy participant samples suitable for athletic training research.

Table 2: Cardiovascular Endurance Changes (Cooper Test - Estimated VO2max ml/kg/min)

Assessment Point	Experimental Group	Control Group	Between-Group Difference	p-value
Baseline	42.3 ± 4.1	41.8 ± 3.9	0.5	0.498
Week 6	45.7 ± 3.8	43.2 ± 4.0	2.5	0.001*
Week 12	48.9 ± 3.6	44.6 ± 3.7	4.3	<0.001*
Within-Group Change	+6.6 (15.6%)	+2.8 (6.7%)	-	-

*Statistically significant at $p < 0.05$

Table 2 presents cardiovascular endurance outcomes measured through estimated VO2max values derived from Cooper 12-minute run test performance. The experimental group demonstrated substantially greater improvements, progressing from 42.3 to 48.9 ml/kg/min representing 15.6% enhancement compared to the control group's 6.7% improvement. Between-group differences achieved statistical significance at both week 6 and week 12 assessments, with the final measurement revealing a 4.3 ml/kg/min advantage for athletes utilizing digital training interventions.

Table 3: Muscular Strength Improvements (One-Repetition Maximum in kg)

Exercise	Group	Baseline	Week 12	Change (%)	p-value
Bench Press	Experimental	62.4 ± 8.3	71.8 ± 7.9	+15.1%	<0.001*
Bench Press	Control	61.9 ± 7.8	66.2 ± 8.1	+6.9%	0.003*
Back Squat	Experimental	84.6 ± 11.2	98.3 ± 10.8	+16.2%	<0.001*
Back Squat	Control	83.9 ± 10.7	90.4 ± 11.0	+7.7%	0.001*

*Statistically significant at $p < 0.05$

Table 3 illustrates muscular strength development across upper and lower body compound movements. Both groups exhibited statistically significant within-group improvements, confirming that structured training produces strength adaptations regardless of digital intervention presence. However, the experimental group achieved markedly superior gains, with bench press improvements of 15.1% versus 6.9% and back squat improvements of 16.2% versus 7.7% for control participants. These findings suggest that digital monitoring and personalized programming optimize resistance training outcomes.

Table 4: Agility Performance (Illinois Agility Test - seconds)

Assessment Point	Experimental Group	Control Group	Difference	Effect Size (d)
Baseline	16.42 ± 0.89	16.51 ± 0.94	-0.09	0.10
Week 6	15.78 ± 0.82	16.19 ± 0.88	-0.41	0.48
Week 12	15.21 ± 0.76	15.87 ± 0.85	-0.66	0.82
Total Improvement	1.21 sec (7.4%)	0.64 sec (3.9%)	-	-

Table 4 documents agility performance changes measured through the Illinois Agility Test, where lower completion times indicate superior performance. The experimental group reduced test completion time by 1.21 seconds representing 7.4% improvement, nearly double the control group's 0.64 second (3.9%) enhancement. Effect size calculations revealed a large magnitude difference ($d = 0.82$) at week 12, indicating practically significant advantages associated with digital training intervention implementation for agility development among university athletes.

Table 5: Sport-Specific Skill Assessment Scores (0-100 scale)

Sport	Group	Pre-Test	Post-Test	Improvement	p-value
Track & Field	Experimental	68.4 ± 7.2	81.3 ± 6.1	+12.9	<0.001*
Track & Field	Control	67.9 ± 6.8	73.6 ± 7.0	+5.7	0.008*
Basketball	Experimental	65.2 ± 8.1	79.8 ± 6.9	+14.6	<0.001*
Basketball	Control	66.1 ± 7.5	72.4 ± 7.3	+6.3	0.012*
Football	Experimental	64.8 ± 7.6	78.2 ± 6.4	+13.4	<0.001*
Football	Control	65.3 ± 7.2	71.1 ± 7.1	+5.8	0.015*

*Statistically significant at $p < 0.05$

Table 5 presents sport-specific skill assessment outcomes across three major disciplines represented in the study sample. Experimental group participants demonstrated consistently superior skill development across all sports examined. Basketball skills showed the greatest differential improvement (14.6 versus 6.3 points), followed by football (13.4 versus 5.8 points) and track and field (12.9 versus 5.7 points). Video-based feedback and technique analysis appear particularly effective for enhancing sport-specific technical proficiency.

Table 6: Training Adherence and Motivation Indicators

Variable	Experimental Group	Control Group	p-value
Session Attendance (%)	94.2 ± 4.8	86.7 ± 6.3	<0.001*
Self-Reported Motivation (1-10)	8.4 ± 1.1	7.1 ± 1.4	<0.001*
Program Satisfaction (1-10)	8.7 ± 0.9	7.3 ± 1.2	<0.001*
Perceived Effectiveness (1-10)	8.5 ± 1.0	6.9 ± 1.3	<0.001*
Intent to Continue (%)	96.7	78.3	0.002*

*Statistically significant at $p < 0.05$

Table 6 reveals psychological and behavioral indicators associated with training intervention modalities. Athletes utilizing digital interventions demonstrated significantly higher training session attendance (94.2% versus 86.7%), suggesting enhanced adherence attributable to engagement features embedded within digital platforms. Self-reported motivation, program satisfaction, and perceived effectiveness all favored the experimental group with statistically significant margins. Additionally, 96.7% of experimental participants expressed intent to continue using digital training tools compared to 78.3% control group continuation intentions.

6. Discussion

The findings of this investigation provide compelling evidence supporting the efficacy of digital training interventions for enhancing physical conditioning, performance outcomes, and skill development among university-level male athletes in India. The experimental group demonstrated statistically significant and practically meaningful advantages across all measured parameters, aligning with theoretical predictions and corroborating findings from international research contexts. Cardiovascular endurance improvements of 15.6% among digital intervention recipients substantially exceed typical training adaptations reported in sports science literature. Düking et al. (2018) reported average improvements of 8-12% in similar university populations following structured endurance training, suggesting that digital monitoring and feedback mechanisms amplify training responses. The continuous heart rate monitoring enabled by wearable devices likely facilitated optimal training intensity maintenance, ensuring athletes consistently worked within prescribed physiological zones rather than relying on subjective effort perceptions (Seshadri et al., 2019).

Muscular strength gains demonstrated similar patterns, with experimental group participants achieving approximately double the improvements observed in control counterparts. These findings align with Windt et al. (2017), who emphasized the importance of training load monitoring for optimizing adaptation without overreaching. The digital applications utilized in this study provided progressive overload recommendations based on performance trends, potentially explaining the enhanced strength development trajectories observed. Agility performance represents a complex athletic quality requiring neuromuscular coordination, reaction time, and movement efficiency. The large effect size ($d = 0.82$) favoring digital intervention participants suggests that technology-enhanced training addresses multiple components contributing to agility expression. Video analysis enabling technique refinement, combined with immediate feedback regarding movement patterns, appears particularly valuable for developing rapid direction change capabilities (Ste-Marie et al., 2012). Sport-specific skill enhancement findings carry significant practical implications for university athletic programs. The substantial advantages observed across track and field, basketball, and football disciplines indicate that video-based feedback mechanisms effectively accelerate technical skill acquisition regardless of sport type. These results extend the motor learning literature by demonstrating that self-observation tools accessible through mobile applications produce comparable benefits to laboratory-based video feedback interventions (Bird, 2017).

The psychological and behavioral outcomes observed warrant particular attention from athletic program administrators. Training adherence represents a persistent challenge in athletic development, with inconsistent

attendance undermining long-term adaptation processes. The 7.5 percentage point adherence advantage associated with digital interventions translates to approximately 9 additional training sessions over the 12-week period, representing substantial accumulated practice time. Gamification elements, progress visualization, and social connectivity features embedded within fitness applications likely contribute to enhanced engagement and motivation maintenance (Direito et al., 2017). Self-determination theory provides a useful framework for interpreting motivation findings. Digital tools may satisfy basic psychological needs for autonomy through personalized training options, competence through visible progress tracking, and relatedness through connected communities of athletes pursuing similar goals (Ryan & Deci, 2017). The significantly higher motivation scores observed among experimental participants suggest that these mechanisms operated effectively within the present intervention context. Program satisfaction and perceived effectiveness indicators have implications for long-term adoption of digital training methodologies. Athletes who perceive training programs as effective and satisfying demonstrate greater commitment to continued engagement, creating positive feedback cycles that sustain performance development over extended periods. The 96.7% intent to continue among experimental participants compared to 78.3% control continuation intentions suggests that digital interventions may enhance athletic program retention rates. Several mechanisms may explain the observed advantages associated with digital training interventions. First, immediate and continuous feedback enables rapid error correction and reinforcement of correct technique, accelerating motor learning processes. Second, objective performance data removes subjective biases from training intensity determination, ensuring appropriate stimulus provision. Third, personalized programming algorithms adapt training prescriptions to individual response patterns, optimizing the training stimulus for each athlete. Fourth, enhanced engagement features maintain motivation during challenging training phases, promoting consistent effort application. The findings carry implications for Indian university athletic programs seeking to enhance competitive performance. Investment in digital training infrastructure appears justified based on the substantial performance advantages observed. However, implementation requires careful consideration of technological literacy, infrastructure availability, and coaching integration to maximize effectiveness. Limitations of the present study include the quasi-experimental design, which precludes definitive causal attribution despite statistical control for baseline differences. The 12-week intervention period, while sufficient for detecting training adaptations, may not capture long-term sustainability of observed effects. Geographic restriction to Madhya Pradesh universities limits generalizability to broader Indian athletic populations. Future research should employ randomized controlled designs, extended follow-up periods, and multi-regional sampling to address these limitations.

7. Conclusion

This investigation demonstrates that digital training interventions significantly enhance physical conditioning, performance outcomes, and skill development among university-level male athletes in India. The experimental group receiving wearable technology monitoring, mobile application-based programming, and video feedback analysis exhibited substantially greater improvements in cardiovascular endurance, muscular strength, agility, and sport-specific skills compared to athletes following traditional training methodologies. Additionally, digital interventions were associated with enhanced training adherence, motivation, and program satisfaction, suggesting psychological benefits complementing physiological adaptations. These findings support the integration of digital training technologies into Indian university athletic programs as evidence-based strategies for optimizing athlete development. University administrators, coaches, and sports scientists should consider systematic implementation of digital tools while ensuring appropriate training for effective utilization. Future research should examine long-term sustainability, cost-effectiveness, and optimal integration strategies to maximize the benefits of digital training interventions for university athletic populations across diverse sporting contexts.

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