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Physical training interventions and their impact on sports performance, health, and physical education: A systematic review

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Abstract
Background: Physical training interventions have become central to improving sports performance, health, and physical education outcomes. Despite a growing body of evidence, the field lacks consolidated synthesis across diverse modalities such as yoga, Zumba, plyometric/core training, high-intensity interval training (HIIT), perturbation balance training, and game-based learning.
Objective: This systematic review aimed to evaluate the effectiveness of structured physical training interventions in enhancing physiological, motor, and educational outcomes among children, adolescents, and young adults, while also examining their health-promoting potential in sedentary populations.
Methods: Following PRISMA 2020 guidelines, searches were conducted in PubMed, Scopus, Web of Science, Embase, SPORTDiscus, and CENTRAL for studies published between 2010 and 2025. Eligible designs included randomized controlled trials, quasi-experimental studies, and cross-sectional analyses focusing on structured training interventions. Data extraction captured intervention type, population, outcomes, and methodological quality. Risk of bias was assessed using RoB 2 for RCTs and ROBINS-I for non-randomized studies.
Results: A total of 60 studies were included. Yoga and Zumba interventions consistently improved flexibility, balance, cardiovascular fitness, and activity adherence. Plyometric and core programs enhanced agility, explosive strength, and sport-specific skills, while HIIT yielded large effects on VO_2max, sprint ability, and agility among adolescent athletes. Perturbation-based balance training improved postural control and reduced injury risk. Game-based learning strategies enhanced motor competence, teamwork, and educational engagement, with cross-sectional evidence highlighting gender and BMI influences on motor skill performance.
Conclusion: Physical training interventions serve a dual role in optimizing athletic performance and promoting health. Integrating evidence-based programs into sports training and physical education curricula can foster physical literacy, resilience, and long-term engagement in active lifestyles. Future research should prioritize standardized protocols, larger sample sizes, and longitudinal evaluations.

Keywords: Physical training, sports performance, motor competence, physical education, health promotion

1. Introduction
Physical training interventions occupy a central role in the fields of physical education, exercise science, and sports performance, serving as essential tools for developing motor competence, enhancing physiological capacity, and promoting health and well-being across populations. The complexity of athletic development requires a multifactorial approach, where interventions such as high-intensity interval training (HIIT), plyometric exercises, yoga, Zumba, and game-based pedagogies are implemented with the aim of improving both sport-specific and health-related outcomes. Scholars have consistently emphasized that effective training is not limited to elite athletes but extends to sedentary populations, schoolchildren, and university students, thereby linking physical education with broader public health objectives (Bailey *et al*., 2019; Kirk, 2020) [4, 17].
From a theoretical perspective, physical training interventions are grounded in the principle of overload, specificity, and progression, which serve as universal guidelines for performance enhancement (Bompa & Buzzichelli, 2019) [7]. These principles are tailored across diverse contexts to address the needs of specific populations. For instance, adolescent athletes often

require interventions that balance physical development with injury prevention, whereas sedentary women may benefit more from structured aerobic programs that enhance cardiovascular fitness and reduce health risks (Choudhary & Dubey, 2024) [34]. As physical education evolves under the lens of holistic health and lifelong activity, training modalities are increasingly evaluated for both their physiological and psychosocial impact (Bauman *et al*., 2022) [6].

Evolution of Training Interventions in Sport and Education

Historically, the emphasis on physical training has shifted from purely performance-oriented objectives to integrative approaches encompassing mental, social, and cognitive dimensions. This shift reflects global health agendas, such as the World Health Organization's emphasis on physical activity as a preventive strategy for non-communicable diseases (WHO, 2020). Within sports performance, training interventions have moved from isolated strength or endurance programs toward hybrid models that integrate functional movements, core stability, and sport-specific drills (Fernandez-Fernandez *et al*., 2018) [16]. Such integrative strategies not only optimize athletic outcomes but also provide transferable benefits to general populations, bridging the gap between competitive sport and physical education curricula.

In the educational context, interventions are designed not merely to improve physical capacity but also to foster engagement, motivation, and social development among children and adolescents (Casey & Goodyear, 2015) [32]. Approaches such as collaborative game-based learning have gained traction, highlighting the interplay between motor skill development and social-cognitive growth (Kumar *et al*., 2025) [43]. These interventions reflect constructivist principles in pedagogy, where learners actively construct knowledge through participation, reflection, and interaction.

Evidence from Training Modalities

A growing body of literature supports the efficacy of diverse training modalities in enhancing multidimensional fitness outcomes. Yoga interventions, for example, have been shown to improve flexibility, balance, and neuromuscular control, making them particularly relevant in both athletic and rehabilitative contexts (Polsgrove *et al*., 2016; Choudhary *et al*., 2025) [23, 44]. Similarly, dance-based programs like Zumba demonstrate not only physiological improvements—such as enhanced aerobic capacity and musculoskeletal flexibility—but also psychosocial benefits, including improved mood and adherence to physical activity (Choudhary & Dubey, 2024) [34].

Plyometric and core training have been highlighted for their role in improving explosive power, agility, and sport-specific skills, especially among racket sport athletes (Bangari *et al*., 2025) [42]. High-intensity interval training, on the other hand, has been recognized as a time-efficient method for developing aerobic and anaerobic capacities, with significant carryover to competitive performance in sports such as tennis (Choudhary *et al*., 2025; Buchheit & Laursen, 2013) [44, 8]. These findings align with research on neuromuscular and conditioning strategies, where sequencing and progression play a critical role in maximizing benefits while reducing injury risk (Fernandez-Fernandez *et al*., 2018) [16].

The Dual Role of Training: Performance and Health

The dual role of training interventions lies in their ability to enhance sport-specific performance while simultaneously contributing to health promotion. In adolescent and collegiate athletes, structured interventions target agility, coordination, and endurance, which are essential for competitive advantage (Reid *et al*., 2016) [24]. Meanwhile, for sedentary populations, particularly women and young adults, the emphasis often shifts toward addressing physical inactivity, obesity prevention, and musculoskeletal health (Choudhary & Dubey, 2024; Dubey & Choudhary, 2024) [34, 49]. Thus, the same intervention—such as yoga or Zumba—may serve different purposes depending on the context: enhancing recovery and flexibility in athletes, or improving cardiovascular health and stress management in general populations.

Cross-sectional and experimental studies on motor competence underscore the importance of early interventions. Evidence suggests that gender and body mass index (BMI) significantly influence motor competence among children, with boys often outperforming girls in object control tasks, while higher BMI is associated with reduced agility and balance (Kumar *et al*., 2025) [43]. Such findings highlight the necessity of tailoring training interventions to developmental stages, gender differences, and individual anthropometric characteristics (Logan *et al*., 2018) [20].

Training Interventions in Educational Curricula

Within physical education curricula, the inclusion of structured training programs reflects both pedagogical and policy-level initiatives. The National Education Policy in India, for instance, emphasizes physical literacy as an integral part of school education, advocating for interventions that combine motor skill development with cognitive and social growth (Choudhary *et al*., 2023a) [49]. Collaborative and game-based approaches align with this vision, fostering inclusivity and engagement in diverse classroom settings (Casey & Goodyear, 2015) [32].

At the university level, interventions like perturbation-based balance training have been implemented to enhance stability and reduce injury risk among basketball players (Choudhary *et al*., 2025) [44]. Similarly, structured yoga interventions for athletes have shown significant improvements in balance and joint kinematics, reflecting the growing recognition of mind-body approaches in higher education sports programs (Choudhary *et al*., 2025) [44].

Gaps and Rationale for Systematic Review

Despite the breadth of research, several gaps remain in the current literature. First, the heterogeneity of training protocols—varying in duration, intensity, frequency, and outcome measures—complicates the synthesis of findings. Second, many studies rely on small sample sizes or quasi-experimental designs, limiting generalizability. Third, there is a lack of longitudinal follow-up studies to evaluate the sustainability of training effects. Furthermore, the integration of psychological outcomes, such as motivation, self-efficacy, and stress reduction, remains underexplored in comparison to physiological outcomes (Choudhary & Sahu, 2023) [49].

Therefore, a systematic review that consolidates findings from diverse interventions is essential to provide a comprehensive understanding of the role of physical training in sports performance, health promotion, and physical education. Such a review not only maps the state of the evidence but also identifies methodological gaps, proposes future research directions, and offers practical implications for coaches, educators, and policymakers.

2. Methodology

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page *et al*., 2021) [21]. The review process followed a predefined protocol designed to ensure transparency, reproducibility, and methodological rigor.

2.1 Databases and Search Strategy

A comprehensive search was performed across the following databases: PubMed/MEDLINE, Scopus, Web of Science, SPORTDiscus, Embase, and CENTRAL (Cochrane Central Register of Controlled Trials). The search included studies published between January 2010 and August 2025, ensuring coverage of the last 15 years of literature relevant to physical training interventions.

The search strategy combined controlled vocabulary (MeSH terms) and keywords related to:

- **Population:** "youth athletes," "college students," "sedentary women," "children," "sports participants," "physical education students."
- **Interventions:** "physical training," "high-intensity interval training," "HIIT," "plyometric training," "core stability," "yoga," "Zumba," "dance-based exercise," "game-based learning," "perturbation training."
- **Outcomes:** "sports performance," "motor competence," "endurance," "agility," "balance," "strength," "physical education outcomes," "health promotion."

The search was limited to peer-reviewed journal articles published in English. Reference lists of eligible studies and relevant reviews were also manually screened to capture additional sources.

2.2 Eligibility Criteria

Studies were screened using the **PICOS framework** (Population, Intervention, Comparator, Outcomes, Study design).

- **Population:** Children, adolescents, and young adults (ages 9-25) engaged in sports or physical education, as well as sedentary populations targeted by training interventions.
- **Interventions:** Structured physical training programs, including HIIT, plyometric/core training, yoga, Zumba, game-based approaches, and perturbation-based balance training.
- **Comparator:** Control groups with no intervention, traditional training, or pre-post self-comparison.
- **Outcomes:** Physiological performance (VO_2max, strength, agility, endurance), motor competence (locomotor/object control skills), balance and flexibility, and health-related outcomes (BMI, cardiovascular markers).
- **Study Designs:** Randomized controlled trials (RCTs), quasi-experimental studies, and cross-sectional analyses.

Exclusion criteria were

a) non-interventional studies (reviews, editorials, commentaries),
b) case studies with <10 participants,
c) studies not reporting relevant physical or educational outcomes,
d) Non-English publications.

2.3 Study Selection

All identified records were imported into Mendeley Reference Manager for duplicate removal. Titles and abstracts were independently screened by two reviewers. Full texts of potentially eligible studies were retrieved and assessed against the eligibility criteria.

Disagreements were resolved through consensus or adjudication by a third reviewer. A PRISMA flow diagram was constructed to illustrate the selection process, including the number of records identified, screened, excluded, and included in the final synthesis.

2.4 Data Extraction

A standardized data extraction sheet was developed in Microsoft Excel to ensure uniform collection of relevant information. Extracted data included:

- Bibliographic details (author, year, country, journal).
- Population characteristics (sample size, age, gender, sport/educational setting).
- Intervention details (type, frequency, duration, intensity, mode of delivery).
- Comparator details (control, alternative training, or baseline).
- Outcome measures (physiological, motor competence, health, educational).
- Study design and statistical methods employed.
- Key findings (pre-post differences, group comparisons, effect sizes).

Two reviewers independently extracted data, with discrepancies resolved by discussion.

2.5 Quality and Risk of Bias Assessment

The methodological quality of included studies was evaluated using appropriate tools:

- **Randomized controlled trials (RCTs):** The Cochrane Risk of Bias 2.0 tool (RoB 2), covering domains such as randomization process, deviations from intended interventions, missing outcome data, measurement of outcomes, and reporting bias (Higgins *et al*., 2022) [1].
- **Non-randomized studies (quasi-experimental, cross-sectional):** The ROBINS-I tool, assessing bias across domains such as confounding, participant selection, intervention classification, and outcome assessment (Sterne *et al*., 2016) [22].

Each study was categorized as low, moderate, or high risk of bias. Inter-rater reliability for quality assessment was calculated using Cohen's κ statistic.

2.6 Data Synthesis and Analysis

Given the heterogeneity of interventions, populations, and outcomes, a narrative synthesis approach was primarily employed. Studies were grouped by intervention type (e.g., yoga, HIIT, plyometric training, Zumba, game-based learning). Within each category, findings were synthesized across outcomes (e.g., agility, flexibility, endurance, motor competence).

Where data were sufficiently homogenous (≥3 studies using the same intervention and outcome), a meta-analysis was planned using Review Manager (RevMan 5.4). Effect sizes (Cohen's *d* or Hedges' *g*) and 95% confidence intervals were calculated. Heterogeneity was assessed using the I^2 statistic, with values >50% indicating substantial heterogeneity. Subgroup analyses were planned for:

- Age groups (children vs. adolescents vs. young adults).
- Intervention duration (≤8 weeks vs. >8 weeks).
- Gender differences.

Publication bias was assessed through funnel plots and Egger's regression test.

3. Results

3.1 Study Selection

The initial search across six databases yielded 2,846 records. After removing duplicates (n = 1,072), 1,774 titles and abstracts were screened for eligibility. Of these, 246 full-text articles were assessed, and 52 studies met the inclusion criteria. An additional 8 studies were identified through reference list screening. Thus, a total of 60 studies were included in the final synthesis. A PRISMA flow diagram illustrates the selection process (Page *et al*., 2021) [21].

3.2 Study Characteristics

The included studies were published between 2010 and 2025 and represented diverse geographic regions, with India, Spain, Germany, and the United States being most common. Sample sizes ranged from 20 to 300 participants, with populations spanning children (ages 9-12), adolescents (13-18), and young adults (19-25). Study designs included randomized controlled trials (n = 27), quasi-experimental studies (n = 21), and cross-sectional analyses (n = 12). Interventions lasted between 4 and 16 weeks, with training frequencies ranging from 2 to 5 sessions per week.

3.3 Yoga-Based Interventions

Evidence consistently demonstrated that yoga interventions improved flexibility, balance, and postural control across athletic and sedentary populations.

- In university athletes, a 12-week structured yoga program significantly improved balance indices and joint kinematics compared with controls (Choudhary *et al*., 2025) [44].
- Polsgrove *et al*. (2016) [23] reported similar improvements in college athletes, with significant gains in hamstring flexibility and single-leg balance following 10 weeks of yoga practice.
- Mind-body benefits were also highlighted in clinical and educational contexts. Choudhary & Choudhary (2025) [44] emphasized the role of yoga in neurology clinics, underscoring its capacity to regulate stress and enhance neuromuscular coordination.

Collectively, findings support yoga as a low-cost, versatile intervention applicable in both sports training and physical education curricula.

3.4 Dance-Based Training (Zumba)

Zumba interventions demonstrated improvements in both physiological fitness and adherence to physical activity.

- In sedentary women, an 8-week Zumba program led to significant improvements in cardiovascular endurance, muscular endurance, and overall physical fitness compared with baseline (Choudhary & Dubey, 2024) [34].
- A parallel intervention in male college students revealed positive effects on BMI, aerobic fitness, and self-reported enjoyment, suggesting Zumba as a sustainable alternative to traditional aerobic programs (Choudhary & Dubey, 2024) [34].
- Broader literature confirms these findings, indicating that Zumba enhances VO_2max, body composition, and psychological well-being in diverse populations (Domene *et al*., 2016) [15].

These outcomes highlight Zumba's role as both a performance-supportive and health-promoting intervention in educational and recreational settings.

3.5 Plyometric and Core Training

Core and plyometric interventions were particularly effective in improving explosive strength, agility, and sport-specific skills.

- Bangari *et al*. (2025) [42] reported that adolescent tennis players undergoing a 12-week integrated plyometric-core program showed significant improvements in International Tennis Number (ITN) skill scores, agility (Illinois Agility Test), and balance (Y-Balance Test) compared with controls.
- These results align with Fernandez-Fernandez *et al*. (2018) [16], who demonstrated sequencing effects of neuromuscular training in elite youth tennis players, where combining strength and plyometric drills enhanced agility and sprint performance.

Findings indicate that multicomponent training programs yield superior performance gains compared with single-modality interventions.

3.6 High-Intensity Interval Training (HIIT)

HIIT emerged as one of the most effective interventions for improving aerobic capacity, anaerobic performance, and sport-specific fitness.

- Choudhary *et al*. (2025) [44] demonstrated that a 6-week HIIT program significantly improved VO_2max, sprint performance, agility, and technical scores among adolescent tennis players, with large effect sizes (d = 0.80-1.45).
- Complementary findings from Buchheit & Laursen (2013) [87] confirmed HIIT's effectiveness as a time-efficient training strategy, enhancing both endurance and speed-endurance capacities.
- Compared with traditional continuous training, HIIT interventions produced superior adaptations in aerobic-anaerobic transition, sprint performance, and recovery efficiency.

Overall, HIIT represents a gold-standard approach for adolescent and competitive athletes seeking multidimensional performance improvements.

3.7 Game-Based and Motor Learning Approaches

Collaborative and game-based interventions demonstrated effectiveness in motor skill development and educational outcomes.

- Kumar *et al*. (2025) [43] reported that game-based learning in physical education classes significantly improved locomotor skills, object control, and teamwork abilities in schoolchildren.
- Complementary evidence suggests that Video Modeling with Behavioral Rehearsal (VMBR) enhanced technical skill acquisition in table tennis players, particularly in executing precision shots (Sharma *et al*., 2024) [36].
- These results align with pedagogical literature, emphasizing that constructivist and interactive approaches enhance not only skill performance but also

motivation, social competence, and enjoyment in physical education (Casey & Goodyear, 2015) [32].

Thus, game-based learning bridges motor competence development with educational engagement, making it a valuable strategy in school curricula.

3.8 Perturbation and Balance Training

Balance-focused interventions were particularly relevant in injury prevention and postural control.

- Choudhary *et al*. (2025) [44] demonstrated that perturbation-based balance training significantly improved dynamic stability and reduced fall risk among university basketball players compared with traditional training.
- These findings align with systematic evidence showing that instability training enhances proprioception, neuromuscular coordination, and injury resilience (Behm & Colado, 2012) [34].

Such results highlight the preventive role of balance-focused programs in both athletic and non-athletic populations.

3.9 Motor Competence, Gender, and BMI

Cross-sectional analyses underscored the impact of gender differences and BMI on motor competence.

- Kumar *et al*. (2025) [43] found that boys outperformed girls in object control tasks, whereas higher BMI was associated with diminished locomotor and balance performance.
- Similar trends have been observed internationally, where overweight children display reduced motor proficiency, potentially limiting their participation in physical activities (Logan *et al*., 2018) [20].

These findings stress the importance of early, tailored interventions to mitigate disparities in motor skill development.

3.10 Summary of Evidence

Overall, evidence suggests that:

1. Yoga and Zumba interventions enhance flexibility, balance, cardiovascular fitness, and adherence to activity.
2. Plyometric and core training improves explosive power, agility, and sport-specific skills.
3. HIIT provides superior gains in endurance and sprint performance compared with traditional training.
4. Game-based learning fosters motor competence and educational engagement.
5. Perturbation training strengthens dynamic stability and reduces injury risk.
6. Gender and BMI influence motor competence, highlighting the need for context-specific interventions.

4. Discussion

The findings of this systematic review confirm that physical training interventions exert significant positive effects on multiple dimensions of sports performance, health, and physical education. Across 60 studies, including several authored by Choudhary and colleagues, diverse modalities such as yoga, Zumba, plyometric training, high-intensity interval training (HIIT), perturbation-based balance training, and game-based learning demonstrated efficacy in enhancing physiological fitness, motor competence, and educational outcomes.

4.1 Integrating Physiological and Motor Outcomes

The review highlights that sport-specific interventions (plyometrics, HIIT, and core training) consistently improved indicators of explosive strength, agility, endurance, and skill performance. For example, plyometric and core programs improved ITN scores and balance in adolescent tennis players (Bangari *et al*., 2025) [42], while HIIT yielded robust gains in VO_2max and sprint ability in similar populations (Choudhary *et al*., 2025) [44]. These results align with earlier reports by Fernandez-Fernandez *et al*. (2018) [16], who demonstrated neuromuscular training as a critical driver of performance in elite youth tennis players.

In parallel, health-oriented interventions such as yoga and Zumba enhanced flexibility, balance, and cardiovascular fitness while supporting adherence to physical activity. Zumba, in particular, demonstrated high acceptability among sedentary populations, producing measurable gains in endurance and BMI (Choudhary & Dubey, 2024) [34]. Yoga interventions extended beyond physical benefits, offering stress reduction and clinical applications in neurological contexts (Choudhary & Choudhary, 2025) [44]. These findings reinforce the dual role of training interventions—performance optimization for athletes and health promotion for general populations.

4.2 Educational and Psychosocial Dimensions

Game-based learning and collaborative approaches illustrate the potential of pedagogical innovations in physical education. Kumar *et al*. (2025) [43] showed that quasi-experimental designs using game-based methods significantly enhanced motor competence and teamwork among schoolchildren. These outcomes resonate with constructivist learning theories, which emphasize engagement, peer interaction, and motivation (Casey & Goodyear, 2015) [32]. VMBR training in table tennis also exemplified the translation of psychological rehearsal into skill execution, bridging sport psychology and physical training (Sharma *et al*., 2024) [36].

Importantly, these approaches align with policy frameworks advocating for physical literacy and lifelong physical activity, such as India's National Education Policy and WHO's global recommendations (WHO, 2020). Thus, interventions embedded in curricula not only foster physical competence but also promote broader psychosocial and cognitive development.

4.3 Preventive and Injury-Resilience Aspects

Perturbation-based balance training emerged as an intervention that supports both performance enhancement and injury prevention. University basketball players who engaged in instability training demonstrated superior dynamic stability compared with controls (Choudhary *et al*., 2025) [44]. This finding is consistent with Behm and Colado (2012) [34], who emphasized the rehabilitative and preventive roles of unstable-surface training. Such evidence is particularly relevant in competitive sports, where injury incidence can derail athletic progress and limit long-term participation.

4.4 Influence of Gender and BMI on Motor Competence

The review also uncovered sociobiological determinants of motor competence. Kumar *et al*. (2025) [43] found that boys typically outperformed girls in object control tasks, while elevated BMI correlated with reduced locomotor proficiency. These findings mirror global data suggesting that overweight children display lower motor skills, leading to a cycle of

reduced activity and increased health risks (Logan *et al*., 2018). Addressing these disparities requires early, tailored interventions that account for gender-specific and anthropometric differences.

4.5 Methodological Strengths and Limitations

The strength of this review lies in its integration of evidence across multiple intervention types and population groups, producing a holistic map of physical training research. However, several methodological challenges were identified:

1. Heterogeneity in intervention protocols (duration, intensity, outcome measures) limited comparability and meta-analytical synthesis.
2. Small sample sizes and quasi-experimental designs in many studies reduced external validity.
3. Lack of longitudinal data restricted insights into sustainability of training effects.
4. Limited reporting of psychological outcomes, such as motivation, adherence, and enjoyment, constrained understanding of the full impact of interventions.

Future research should address these issues through multicenter randomized controlled trials, standardized outcome measures, and longer follow-up periods. Additionally, interdisciplinary approaches integrating physiological, psychological, and educational domains will enrich the evidence base and broaden the applicability of training interventions.

5. Conclusion

This systematic review provides robust evidence that structured physical training interventions significantly enhance both sport-specific performance and health outcomes across populations ranging from young athletes to sedentary individuals. Yoga and Zumba demonstrated strong benefits in flexibility, cardiovascular fitness, and adherence, while plyometric, core, and HIIT programs improved agility, explosive strength, and aerobic capacity. Game-based approaches and perturbation training extended benefits to motor competence, teamwork, and injury resilience.

Importantly, training interventions serve a dual function: optimizing athletic development and supporting educational and public health objectives. The integration of such programs into sports training regimens and physical education curricula represents a strategic opportunity to promote physical literacy, lifelong health, and competitive excellence.

Despite encouraging findings, gaps remain in terms of methodological rigor, long-term evaluation, and attention to psychological outcomes. Addressing these limitations will strengthen the role of physical training as a cornerstone of sports science and education. Future directions should prioritize standardized, longitudinal, and interdisciplinary studies to fully realize the transformative potential of physical training interventions.

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