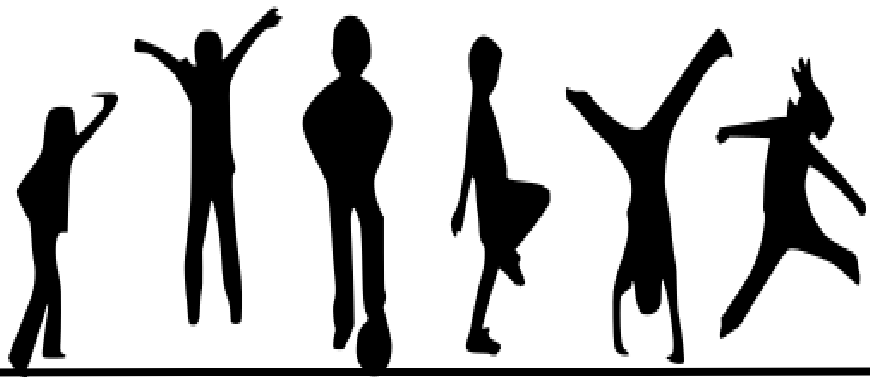
# Athens Journal of Sports

Quarterly Academic Periodical, Volume 13, Issue 2
Published by the Athens Institute
URL: https://www.athensjournals.gr/ajspo Email: journals@atiner.gr
e-ISSN: 2241-7915 DOI: 10.30958/ajspo



# Athens Journal of Sports

Quarterly Academic Periodical, Volume 13, Issue 2, June 2026

Published by the Athens Institute

URL: https://www.athensjournals.gr/ajspo Email: journals@atiner.gr

e-ISSN: 2241-7915 DOI: 10.30958/ajspo

## Front Pages

# Athens Journal of Sports

*Published by the Athens Institute*



*Athens Institute is an Athens-based World Association of Academics and Researchers based in Athens. Athens Institute is an independent and non-profit Association with a Mission to become a forum where Academics and Researchers from all over the world can meet in Athens, exchange ideas on their research and discuss future developments in their disciplines, as well as engage with professionals from other fields. Athens was chosen because of its long history of academic gatherings, which go back thousands of years to Plato's Academy and Aristotle's Lyceum. Both these historic places are within walking distance from Athens Institute's downtown offices. Since antiquity, Athens was an open city. In the words of Pericles, Athens"…is open to the world, we never expel a foreigner from learning or seeing". ("Pericles' Funeral Oration", in Thucydides, The History of the Peloponnesian War). It is Athens Institute's mission to revive the glory of Ancient Athens by inviting the World Academic Community to the city, to learn from each other in an environment of freedom and respect for other people's opinions and beliefs. After all, the free expression of one's opinion formed the basis for the development of democracy, and Athens was its cradle. As it turned out, the Golden Age of Athens was in fact, the Golden Age of the Western Civilization. Education and (Re)searching for the 'truth' are the pillars of any free (democratic) society. This is the reason why Education and Research are the two core words in Athens Institute's name.*

The *Athens Journal of Sports* (AJSPO) is an Open Access quarterly double-blind peer reviewed journal and considers papers from all areas of sports and related sciences. Many of the papers published in this journal have been presented at the various conferences sponsored by the Sport, Exercise, & Kinesiology Unit of the Athens Institute & the Panhellenic Association of Sports Economists and Managers (PASEM). All papers are subject to Athens Institute's Publication Ethical Policy and Statement.

Athens Journal of Sports
ISSN NUMBER: 2241-7915 - DOI: 10.30958/ajspo
Volume 13, Issue 2, June 2026
Download the entire issue (PDF)

# Athens Journal of Sports

## Editorial and Reviewers' Board

# President's Message

All Athens Institute's publications including its e-journals are open access without any costs (submission, processing, publishing, open access paid by authors, open access paid by readers etc.) and is independent of presentations at any of the many small events (conferences, symposiums, forums, colloquiums, courses, roundtable discussions) organized by Athens Institute throughout the year and entail significant costs of participating. The intellectual property rights of the submitting papers remain with the author. Before you submit, please make sure your paper meets the basic academic standards, which includes proper English. Some articles will be selected from the numerous papers that have been presented at the various annual international academic conferences organized by the different divisions and units of the Athens Institute for Education and Research. The plethora of papers presented every year will enable the editorial board of each journal to select the best, and in so doing produce a top-quality academic journal. In addition to papers presented, Athens Institute will encourage the independent submission of papers to be evaluated for publication.

The current issue is the second of the thirteenth volume of the *Athens Journal of Sports (AJSPO),* published by the Sport, Exercise, & Kinesiology Unit of the Athens Institute under the aegis of the Panhellenic Association of Sports Economists and Managers (PASEM).

Gregory T. Papanikos
President
Athens Institute

**Athens Institute for Education and Research**

*A World Association of Academics and Researchers*

## 27th Annual International Conference on Sports: Economic, Management, Marketing & Social Aspects 10-13 May 2027, Athens, Greece

The Sports Unit of ATINER organizes its **27th Annual International Conference on Sports: Economic, Management, Marketing & Social Aspects, 10-13 May 2027, Athens, Greece** sponsored by the Athens Journal of Sports. The aim of the conference is to bring together academics and researchers of all areas of sports. Please submit a proposal using the form available (https://www.atiner.gr/2027/FORM-SPO.doc).

### Academic Members Responsible for the Conference

**Dr. Gregory T. Papanikos | Dr. Maria Konstantaki | Dr. Chris Sakellariou | Dr. Sharon Claire Bolton | Dr. Valia Kasimati | Dr. Cleopatra Veloutsou | Dr. Christos Anagnostopoulos**

### Important Dates

- Abstract Submission: **13 October 2026**
- Acceptance of Abstract: 4 Weeks after Submission
- Submission of Paper: **12 April 2027**

### Social and Educational Program

The Social Program Emphasizes the Educational Aspect of the Academic Meetings of Athens Institute.

- Greek Night Entertainment (This is the official dinner of the conference)
- Athens Sightseeing: Old and New-An Educational Urban Walk
- Social Dinner
- Mycenae Visit
- Exploration of the Aegean Islands
- Delphi Visit

### Conference Fees

Conference fees vary from 400€ to 2000€

Details can be found at: https://www.atiner.gr/fees

## Athens Institute for Education and Research
*A World Association of Academics and Researchers*

### 22nd Annual International Conference on Sport & Exercise Science
### 27-31 July 2026, Athens, Greece

The Sports Unit of ATINER will hold its **22nd Annual International Conference on Sport & Exercise Science, 27-31 July, Athens, Greece** sponsored by the Athens Journal of Sports. You may participate as stream leader, presenter of one paper, chair a session or observer. Please submit an abstract (email only) to: atiner@atiner.gr, using the abstract submission form (https://www.atiner.gr/2026/FORM-FIT.doc).

**Important Dates**

- Abstract Submission: **DEADLINE CLOSED**
- Acceptance of Abstract: 4 Weeks after Submission
- Submission of Paper: **23 June 2026**

**Academic Member Responsible for the Conference**

- Dr. Maria Konstantaki, Academic Member, Athens Institute & Senior Lecturer, Buckinghamshire New University, UK.

**Social and Educational Program**

The Social Program Emphasizes the Educational Aspect of the Academic Meetings of Athens Institute.

- Greek Night Entertainment (This is the official dinner of the conference)
- Athens Sightseeing: Old and New-An Educational Urban Walk
- Social Dinner
- Mycenae Visit
- Exploration of the Aegean Islands
- Delphi Visit
- Ancient Corinth and Cape Sounion

More information can be found here: https://www.atiner.gr/social-program

**Conference Fees**

Conference fees vary from 400€ to 2000€

Details can be found at: https://www.atiner.gr/fees

*Athens Journal of Sports - Volume 13, Issue 2, June 2026 – Pages 81-100*

# The Association between Sleep Hygiene and Sport Participation in Girls: A Rapid Review of the Literature

*By Jayda Hylton-Pelaia*, Lauren Shields±, Caroline Barakat• & Efrosini Papaconstantinou○*

***Introduction:*** *Sport participation and healthy sleep hygiene behaviours are important for girls' growth and development. Given the importance of both, this rapid review synthesized existing evidence on the association between sleep hygiene and sport participation in girls aged 6 to 12 years.* ***Methods:*** *We conducted a rapid review registered on the Open Science Framework (OSF) and reported our findings following PRISMA guidelines. MEDLINE, PsycINFO, and SportDiscus were searched from inception to March 8, 2025, and updated in February 2026. We included cross-sectional, cohort, and case-control studies. Two reviewers screened citations. Risk of bias was appraised using CASP checklists. Findings were synthesized.* ***Results:*** *The search retrieved 1401 articles, with an additional 118 records identified through an updated search (n=1519). Three studies met inclusion criteria, were critically appraised, and synthesized. Findings were mixed. Higher sleep efficiency was associated with participation in school-based sport, whereas shorter sleep duration, greater daytime tiredness, and sleep-related impairments were associated with involvement in specialized or competitive sport contexts.* ***Conclusion:*** *This review highlights limited evidence on the association between sleep hygiene and sport participation in girls aged 6-12 years. Further research is needed to clarify this relationship, and targeted interventions need to be developed.*

**Keywords:** *sleep; sport participation; girls; middle childhood*

## Introduction

Regular physical activity, including sport participation, defined as the purposeful participation in a sports-related activity (Deelen et al., 2018), is crucial during childhood and adolescence. Engaging in sports not only enables children and adolescents to meet physical activity recommendations, but it also influences other aspects of one's life, including social connections and overall quality of living (Mohammed, Barakat, & Stanyon, 2020). Furthermore, it promotes a healthier lifestyle for children, helps to lower the prevalence of non-communicable diseases (such as cancer, osteoporosis, coronary heart disease, or cardiovascular disease), and enhances psychological well-being (Chen et al., 2021; Griffith et al, 2021).

In addition to sport participation, maintaining good sleep hygiene is essential for sleep quality in adolescents, as it influences various aspects of their lives,

*PhD Candidate, Faculty of Health Sciences, Ontario Tech University, Canada.
±Medical Laboratory Science Student, The Michener Institute of Education, Canada.
•Professor, Faculty of Health Sciences, Ontario Tech University, Canada.
○Associate Professor, Faculty of Health Sciences, Ontario Tech University, Canada.

including academic performance, emotional well-being, and overall enjoyment of physical activities (Blackwell et al., 2020). Sleep hygiene is defined as environmental and behavioural practices that promote healthy sleep. For example, having the same sleep and wake time and avoiding caffeine and alcohol too close to bedtime, while environmental factors include the sleep environment, such as comfortable temperature, dark light, and a reduction in noise levels (De Pasquale et al., 2024). It is important to note that insufficient sleep has been associated with several negative health outcomes, such as poorer general health, irregular moods, and an increased risk of illness (Biggins et al., 2019; Pagerols et al., 2023). Insufficient sleep increases the risk of conditions such as obesity, poor cardiovascular health, anxiety, depression, and cognitive impairments, such as memory and recognition (Ordway et al., 2022).

Further, children who are sedentary are more likely to have unhealthy dietary habits, a higher likelihood of consuming fast food, and fewer sleeping hours compared to children who are physically active (Kosti et al., 2023). Despite this, studies have shown that children and adolescents who participate in sports struggle to obtain sufficient sleep, and the quality of their sleep is often less than ideal (Biggins et al., 2019; Roberts et al., 2019).

Middle childhood (age 6-12) is a particularly important developmental stage for examining sleep and sport participation because behavioural routines, health habits, and participation patterns are established during this period (Griffith et al., 2021). Additionally, girls' sport participation frequently declines during adolescence, making early identification of factors associated with positive sport participation experiences important (Mohammed, Barakat, & Stanyon, 2020; Westerbeek & Eime, 2021).

While there are known benefits for both sleep hygiene practices for healthy sleep and sport participation, middle childhood-aged girls (ages 6-12 years old) face challenges in achieving optimal levels of both. There is a concerning trend regarding girls' sport participation, as during adolescence, participation for girls drops by 22% (Mohammed, Barakat, & Stanyon, 2020). In terms of sleep hygiene, school-aged children between 6 to 12 years old face sleep problems at an alarming rate, with 37% experiencing issues such as bedtime resistance, which leads to sleep onset delay, sleep anxieties, and ultimately daytime sleepiness from sleep insufficiency (Ophoff et al., 2018). Given the importance of both healthy sleep hygiene for good sleep quality and sport participation behaviours for the health and well-being of middle childhood-aged girls, it is crucial to understand if these two factors interact. The benefits of sleep hygiene and sport participation have been well-researched separately; however, the gap in the investigation of the relationship between sleep hygiene and sport participation in young girls is apparent. Research examining the association between sport participation and sleep has predominantly focused on adolescents or adult athletes, often within performance-oriented contexts (e.g., recovery and competition demands), whereas studies involving children more commonly investigate general physical activity and sleep rather than organized sport specifically, and frequently rely on mixed-gender samples (Kredlow et al., 2015; Chandrasekaran et al., 2020; Fonseca et al., 2021).

To our knowledge, no previously published systematic reviews have investigated the association between sleep hygiene practices and sport participation among middle childhood girls. Given the importance of sleep health and the declining prevalence of sport participation in girls, investigating this association among young girls between the ages of 6 and 12 years is important. Therefore, the objective of this study was to evaluate and synthesize the existing evidence on the association between sleep hygiene practices and sport participation among girls aged 6-12 years.

## Methods

### Study Design

We conducted a rapid review of the literature. A rapid review was chosen due to its ability to accelerate the synthesis of existing literature without sacrificing the quality of findings (Ganann et al., 2010). A rapid review is a type of knowledge synthesis in which components of the systematic review process are simplified or omitted to produce information in a short period of time (Lagisz et al., 2022). We followed the methodology recommended by the World Health Organization (Tricco et al., 2017). The review was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. A full protocol for the systematic review was registered with Open Science Framework (OSF) and placed under embargo (OSF; registration ID: 5wae2).

### Eligibility Criteria

Eligible studies met the following predefined criteria: 1) investigated middle childhood (between 6 and 12 years of age) girls; 2) study of the association of sleep hygiene and sports participation; 3) published in English or translatable; and 4) cross-sectional, case-control, or cohort studies published in peer-reviewed journals.

We excluded guidelines, letters, editorials, unpublished manuscripts, dissertations, and government reports, pilot studies, case reports, case series, qualitative studies, systematic reviews focused on clinical populations, cadaveric or animal studies and studies not reporting on methodology.

*Population: Middle Childhood Girls*

The target population was middle childhood girls between the ages of 6 and 12 years, consistent with developmental classifications that define middle childhood as the period spanning approximately 6 to 12 years, characterized by continued cognitive, social, and physical development before adolescence (Mah & Ford-Jones, 2012). For studies that included other age groups (e.g., 12 to 14 years), we included those that provided stratified results for our eligible age group. Studies with mixed-gender populations were included only if data for girls within the specified age range were reported separately.

*Exposure: Sleep Hygiene*

**Sleep hygiene** was defined as modifiable behaviours or environmental conditions that influence sleep. This included sleep duration, quality, timing, efficiency, and bedtime routines. However, the available literature in this age group primarily measures sleep using observable sleep characteristics rather than direct assessments of sleep hygiene behaviours. Therefore, for this review, sleep hygiene exposure was operationalized using sleep-related outcomes and sleep characteristics that are commonly used as indicators of sleep health and are influenced by underlying sleep hygiene practices. Although these sleep outcomes are not synonymous with sleep hygiene, they reflect the potential to influence behavioural and environmental sleep practices and are frequently used in pediatric sleep research as proxy indicators of sleep health (Irish et al., 2015). Findings should therefore be interpreted cautiously, recognizing that direct behavioural sleep hygiene was not measured in the included studies. Studies were included if they used subjective measures (e.g., questionnaires, self/parent reports) or objective tools (e.g., actigraphy, wearable devices) to assess any aspect of sleep hygiene or related factors.

*Outcome: Sport Participation*

**Sport participation** was defined as engagement in organized or recreational sports outside of mandatory physical education classes (Deelen et al., 2018). This included competitive sports, recreational leagues, individual sports with structured training, and non-competitive multi-sport camps. Studies measuring general physical activity without reference to sport participation were excluded.

## Search Strategy

A search strategy was developed in consultation with a health sciences librarian. Searches were initially conducted in three electronic databases from inception to March 8, 2025: MEDLINE (via OVID), PsycINFO (via ProQuest), and SportDiscus (via EBSCO). These databases were selected to ensure comprehensive coverage of medical, psychological, and sport-specific literature relevant to the review topic. The search strategy included keywords and subject headings related to sleep hygiene, sport participation, and girls age 6-12 years. Before manuscript submission, an updated search was conducted in February 2026 to identify any newly published studies and ensure the review reflected the most current available evidence. The updated search used the same databases, search strategy, and eligibility criteria as the original search. The full search strategy is presented in Appendix A.

## Data Collection and Analysis
### Study Selection

Pairs of trained, independent reviewers screened articles in two phases to determine eligibility. In phase I, paired reviewers (L.S. and J.H) screened titles and abstracts to determine "possibly relevant" and "irrelevant" citations independently based on the predetermined eligibility criteria. In phase II, paired reviewers (L.S. and J.H.) reviewed possibly relevant citations from phase I using the full text article to determine whether the source was relevant, documenting the reasons for exclusion. Any disagreements during screening were resolved by discussion between the paired reviewers to reach consensus. If consensus could not be reached, a third reviewer was consulted.

### Methodological Quality and Risk of Bias Appraisal

Risk of bias was assessed by a single reviewer (L.H) using checklists developed by the Critical Appraisal Skills Programme (CASP) to inform judgment on the internal validity of each included study. The use of a single reviewer for appraisal was consistent with rapid review methodology, incorporating a streamlined process to accelerate evidence synthesis while maintaining methodological rigor (Ganann et al., 2010). Before formal appraisal, the reviewer pilot-tested the CASP tools to ensure familiarity and consistent application of criteria. Any uncertainties regarding appraisal decisions were discussed with a second reviewer (J.H) until consensus was reached. Studies were rated as having low, moderate, or high risk of bias based on factors such as study design, sampling strategy, measurement reliability, and control of confounding variables. In accordance with the review protocol, only studies that were categorized as low or moderate risk of bias were to be included in the final synthesis.

### Data Extraction

A researcher (L.H) extracted data from the included studies and entered the relevant information into a prepared evidence table. A second reviewer reviewed the table for accuracy and completeness (J.H.). The data extraction table was used to report components of each study including study design, population characteristics, measures of sleep hygiene and sport participation, and key findings regarding their association.

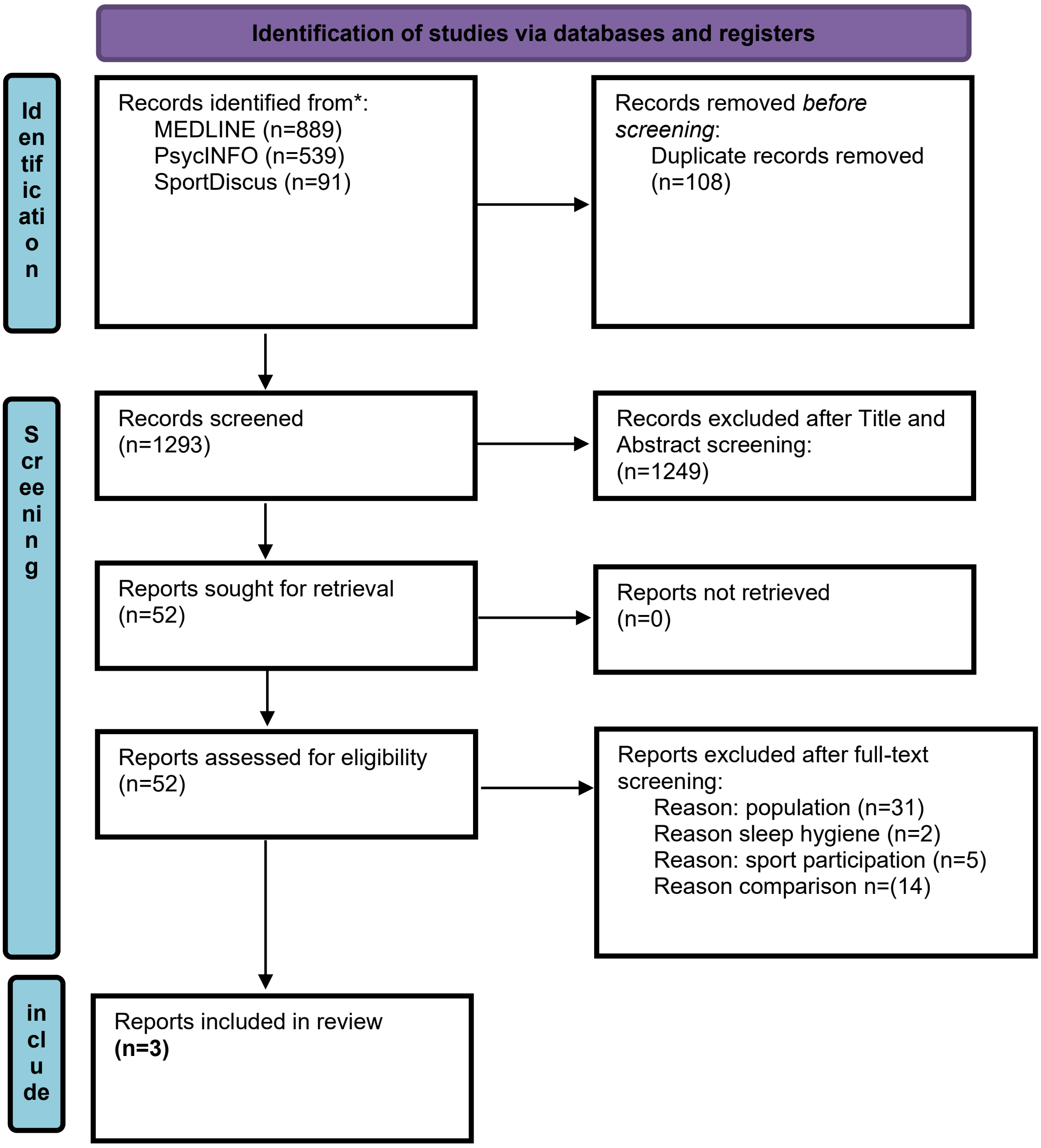
### Evidence Synthesis

Synthesis Without Meta-Analysis (SWiM) was used for a structured, transparent narrative synthesis of included studies (Campbell et al., 2020), providing an overview of the association between sleep hygiene and sport participation among middle childhood girls.

## Results
### Study Selection

The search retrieved 1401 records. After removing duplicates, 1293 titles and abstracts were screened for eligibility. Of these, 44 full-text articles were reviewed, and three met the eligibility criteria and proceeded to the risk of bias appraisal. An updated search conducted in February 2026 identified 118 additional records published since the initial search. Eight articles were reviewed in full text; however, none met the eligibility criteria. Therefore, the final synthesis remained unchanged and included three studies. The screening and selection process is summarized in Figure 1 (PRISMA flow diagram). The most common reasons for full-text exclusion were ineligible population (n=31) and lack of comparison or analysis between sleep hygiene and sport participation (n=14).

**Figure 1.** *PRISMA Flow Diagram*



## Quality Assessment

The methodological quality of the three included studies was evaluated using the CASP Cohort and CASP Cross-sectional checklists. A detailed appraisal of each study is presented in Appendix B. Of the three studies, one was rated as low risk of bias, and two were rated as moderate risk of bias. No studies were categorized as high risk of bias to warrant exclusion from the review.

## Study Characteristics

Three studies met the inclusion criteria: two cohort studies (Watson et al., 2021; Falstrom et al., 2022) and one cross-sectional study (Larrinaga-Undabarrena et al., 2023), published between 2021 and 2023. Detailed study characteristics are presented in Table 1. The studies were conducted in the United States, Sweden, and Spain. Sample sizes ranged from 233 middle school athletes to 1082 school-children, with all studies including girls within or overlapping with the target age range of 6 to12 years. Where studies included broader age ranges, only results relevant to the review focus were considered.

The measurement of sleep-related characteristics varied with Falstrom et al. (2022) and Watson et al. (2021) using self- or parent-reported methods (daily/ weekly sleep duration, sleep difficulties, tiredness), while Larrinaga-Undabarrena et al. (2023 employed objective accelerometry capturing measures of sleep duration, sleep efficiency, and wake after sleep onset. None of the included studies directly assessed behavioural sleep hygiene practices.

Sport participation measurement was operationalized through club membership, weekly training hours, or organized activity participation across studies (e.g., competitive football, school-based sport participation, weekly sport specialization).

**Table 1.** *Summary of Study Characteristics from included Studies*

| Author, Year | Study Design | Aim | Location | Population | Sleep Hygiene | Sport Participation | Main Findings relevant to Review |
|---|---|---|---|---|---|---|---|
| Falstrom, 2022 | Cohort (1 year) | To describe lifestyle factors, including sleep, in adolescent female football players and changes over 1 year | Sweden | 419 girls, 12-17 (97 aged 12) | Self-reported sleep problems (difficulty falling asleep, waking up at night and trouble returning to sleep, daytime tiredness), and duration (sleeping hours per night) also recorded.<br><br>Sleep measured using a five-point scale (1=never, 5=every day)<br><br>Impaired sleep defined as: frequent problems falling asleep or staying asleep several times per week, and rated tiredness in daily activities several times per week or every day. | Weekly club football participation, years in club.<br><br>Mean years playing football: 7 (SD 2.2). Average football training: 5 hours per week; 1.5 matches per week. | Sleep insufficiency and tiredness common among competitive girl athletes; tiredness increased over 1 year.<br><br>Sleep issues were common, with 16% sleeping less than 8 hours per night, 8% experiencing impaired sleep with daytime consequences, and 22% feeling tired during daily activities.<br><br>Sleep problems and insufficient sleep increased at 1-year follow-up. The proportion of players feeling tired during the day increased over 1 year (20% to 27%). |
| Larrinaga-Undabarrena, 2023 | Cross-sectional observational study | To compare physical activity and sleep in schoolchildren by | Basque Country, Spain | 1082 children (49.9% girls), 6-17 (subset: 6-12) | Objective (accelerometer) Variables recorded: sleep | Physical/sport activity participation (yes/no) | Girls (6–12) who participated in sport had higher sleep efficiency |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | sport participation status | | | efficiency, total sleep time, WASO (wake after sleep onset)<br><br>Sleep diaries complemented accelerometer data for context. | Participants categorized as PSA (physical sport activity) practitioners or non-practitioners. | and less sedentary time than non-participants.<br><br>PSA practitioners showed significantly better sleep efficiency and lower sedentary time compared to non-practitioners.<br><br>No significant difference in total sleep time or WASO between PSA and non-PSA groups.<br><br>Children aged 6-12 showed higher sleep parameters and less sedentary behavior compared to adolescents irrespective of sex.<br><br>Girls participated similarly in PSA and showed similar trends in sleep efficiency improvements when engaged in physical sports. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Watson, 2021 | Prospective cohort conducted over an academic year (39 weeks) | To evaluate effects of sport specialization, sleep, and physical activity on illness in middle school athletes | Wisconsin, USA | 233 athletes 10-14 (39% girls) | Weekly electronic parent-reported surveys on the child's average sleep duration during the prior week.<br><br>Sleep Variables: Weekly average sleep duration (hours). | Weekly hours of organized physical activity reported by parents; sport specialization level categorized as low, moderate, or high using established criteria.<br><br>Weekly organized and unorganized physical activity hours recorded. | Specialized athletes tended to have slightly lower average sleep duration.<br><br>More sleep and PA independently predicted lower illness risk; specialization had no effect. |

### Summary of Evidence

Three studies met the eligibility criteria and provided preliminary evidence relevant to the association between sleep-related indicators and sport participation among girls in middle childhood between the ages of 6 and 12 years.

In the cross-sectional accelerometer-based study by Larrinaga-Undabarrena et al. (2023) found that girls who participated in school-based sport exhibited a higher mean sleep efficiency of 87.16% (SD = 5.84) compared to 86.12% (SD = 6.81) among non-participants, representing a mean difference of 1.04 percentage points ($p = 0.022$). No significant differences were observed for total sleep time or wake after sleep onset.

In the prospective cohort study, Watson et al. (2021) found that girls who were more specialized in sport reported slightly shorter average sleep duration compared to those with lower levels of specialization (high specialization: 8.48 hours [95% CI, 8.3-8.6 hours]; moderate specialization: 8.71 hours [95% CI, 8.6-8.9 hours]; low specialization: 8.63 hours [95% CI, 8.5-8.8 hours]).;). Pairwise comparisons indicated a statistically significant difference in sleep duration between low- and high-specialization groups ($p = 0.045$), while other group comparisons were not statistically significant.

Falstrom et al. (2022) reported indicators of compromised sleep among girls who participated in competitive football, including insufficient sleep, daytime tiredness, and sleep-related impairment. At one year follow-up, the proportion of girls reporting daytime tiredness several times per week or daily increased from 20% to 27%.

Overall, findings across the included studies were mixed with some studies reporting associations between sleep-related indicators and sport participation among middle childhood girls.

## Discussion

This rapid review aimed to explore the association between sleep hygiene and sport participation among middle childhood girls. Three studies met the eligibility criteria and were included following quality appraisal, each investigating this association using different designs, measurement approaches, and varied operationalizations of sleep hygiene (e.g., sleep duration, sleep efficiency), as well as different sport contexts. Importantly, the findings synthesized in this review primarily reflect associations between sport participation and sleep characteristics rather than direct measures of behavioural sleep hygiene. The findings were mixed. In the accelerometer-based study, girls with higher sleep efficiency were more likely to participate in school-based sport compared to girls with lower sleep efficiency. In contrast, cohort studies involving specialized or competitive athletes indicated that girls reporting shorter sleep duration, greater daytime tiredness, or sleep-related impairments were engaged in higher levels of organized or specialized sport participation. Considerable heterogeneity existed across study designs, sport contexts, and sleep measures, limiting direct comparison. The small number of eligible studies, combined with variability in methodology and sleep measurement, highlights the need for additional high-quality research to better understand the association between sleep hygiene indicators and sport participation among girls in middle childhood.

A notable challenge in interpreting the evidence across the included studies is that none of the studies directly assessed sleep hygiene as a multidimensional construct. Validated measures of sleep hygiene (e.g., the Sleep Hygiene Index) conceptualize it as a behavioural construct distinct from sleep outcomes such as duration or efficiency (Mastin et al., 2006). Instead, the included studies measured selected components of sleep (e.g., sleep duration, sleep efficiency, sleep difficulties, or daytime tiredness) that are related to but not synonymous with sleep hygiene. As a result, interpretations about sleep hygiene must be drawn from the specific sleep indicators used in each study.

Across the included studies, sleep was measured using three different approaches: objective accelerometry (Larrinaga-Undabarrena et al., 2023), parent-reported sleep duration (Watson et al., 2021), and self-reported sleep difficulties and tiredness (Faltstrom et al., 2022). Although each of these indicators reflects aspects of girls' sleep, none of the studies directly assessed sleep hygiene (e.g., the Sleep Hygiene Index or CSHQ bedtime routine items). As such, this review synthesizes evidence based on sleep characteristics that may be influenced by underlying sleep hygiene behaviours rather than on direct measures of sleep hygiene itself. Therefore, findings should be interpreted as reflecting associations between sleep characteristics and sport participation, recognizing that the sleep measures assessed may reflect the influence of underlying sleep hygiene behaviours rather than direct measurement of those behaviours.

Larrinaga-Undabarrena et al. (2023) used objective measurement using accelerometry which is considered best practice in sleep research, particularly for children (Miller et al., 2024). This provided reliable estimates of sleep efficiency, total sleep time, and wake after sleep onset. Although these metrics are not direct measures of sleep hygiene, they are influenced by sleep-hygiene behaviours such as consistent bedtime routines, limited evening stimulation, and appropriate sleep timing (Irish et al., 2015). Thus, girls with higher sleep efficiency were more likely to participate in school-based sport, suggesting that better sleep efficiency may reflect underlying behavioural routines consistent with healthy sleep hygiene practices. Although statistically significant, the magnitude of difference in sleep efficiency was modest.

In contrast, Watson et al. (2021) relied on parent-reported which is more vulnerable to recall bias. The parent-reported sleep duration, collected weekly, captures one dimension of sleep patterns but does not provide insight into behaviours that promote sleep quality (e.g., bedtime routines, screen use, caffeine, or sleep environment). Sleep duration can be influenced by both sleep hygiene (such as consistent bedtimes) and structural constraints (such as training schedules), making interpretation more complex (De Pasquale et al., 2024; Milewski et al., 2014). Lower sleep duration among specialized athletes may partly reflect behavioral disruptions inconsistent with good sleep hygiene, such as late practices or competing demands between school and sport.

Similarly, Faltstrom et al. (2022) used self-reported sleep difficulties, tiredness, and sleep-related impairment, which represent perceived sleep problems and daytime functioning rather than sleep hygiene behaviours. These indicators reflect the consequences of poor sleep hygiene rather than the behaviours themselves. These indicators are subjective and can be influenced by stress, mood, or training load. Frequent tiredness or sleep impairment may signal inconsistent routines, high stress, insufficient recovery time, or environmental disruptions, which are factors that are common with high-intensity sport participation.

With each study capturing different sleep hygiene-related indicators, the sport contexts in which girls participated (school-based, specialized, or competitive) also varied, further shaping the observed associations.

Larrinaga-Undabarrena et al. (2023) found that girls who participated in school-based sport demonstrated higher sleep efficiency than non-participating peers. This aligns with previous research showing that regular physical activity like structured sport participation is associated with improved sleep quality and sleep efficiency among children and adolescents (Brand et al., 2014; Lang et al., 2016). A systematic review on sleep and health-related physical fitness in children and adolescents (Fonseca et al., 2021) concluded that longer sleep and better sleep quality were associated with higher levels of physical fitness among children and adolescents, which indirectly supports the tie between being active (often via sport) and sleep.

In contrast, shorter sleep duration and greater sleep-related difficulties were observed among girls engaged in specialized or competitive sport contexts (Watson et al., 2021; Faltstrom et al., 2022). Girls engaged in higher-intensity or specialized sport tended to report shorter sleep duration, greater sleep difficulties, or daytime tiredness. Competitive and specialized sport often requires evening practices, greater training volume, performance expectations, and additional psychosocial demands, all of which may disrupt routines and interfere with sleep hygiene (Meisel et al., 2022). School-based programs tend to support healthy sleep hygiene because they are typically low-barrier, embedded within the school day, and free of additional costs or late-evening commitments (Dobbins et al., 2021). The structure of these environments, such as, consistent schedules, predictable routines, supervised activity, and moderate physical exertion, supports healthy sleep regulation and may help reinforce sleep-hygiene practices, potentially explaining the observed improvements in sleep efficiency. Unlike school-based programs, competitive and specialized sports typically occur outside of school hours and may place less emphasis on balancing academic schedules, making it more challenging for girls to maintain healthy sleep-wake patterns.

Further, Faltstrom et al. (2022) reported that, at one-year follow-up, a greater proportion of girls experienced daytime tiredness “every day” or “several times per week,” suggesting that cumulative training loads and competitive pressures may erode sleep quality over time. High-performance environments often involve elevated expectations, intensified schedules, and occasional travel or competition-related disruptions, all of which can make consistent sleep routines difficult to sustain. Based on the studies included in this review, it can be inferred that girls involved in school-based sport may be more likely to maintain healthier sleep practices compared to those participating in more specialized or competitive sport settings.

The absence of additional eligible studies in the updated search further underscores the limited and underdeveloped evidence base examining sleep hygiene indicators in relation to sport participation among middle childhood girls.

## Strengths

This rapid review has several strengths. First, the review protocol was prospectively registered and reported in accordance with PRISMA guidelines, enhancing transparency and methodological rigor. Second, study selection was conducted by independent reviewers, reducing the risk of selection bias. Third, risk of bias appraisal was systematically performed using validated CASP checklists, with transparent reporting of study quality.

Additionally, this review focused specifically on middle childhood girls between the ages of 6 and 12 years a population that is often underrepresented in sport and sleep research. By distinguishing between behavioural sleep hygiene practices and measurable sleep characteristics, this review provides important conceptual clarity and highlights a critical gap in the existing literature. The inclusion of both subjective and objective sleep measures further strengthens the comprehensiveness of the synthesis.

## Limitations

This rapid review has several limitations. Firstly, the included studies varied widely in design, sport context, and sleep measurement methods (objective, parent-report, self-report), which may have contributed to the mixed findings. Secondly, the sport contexts differed substantially. School-based sport, specialized sport, and competitive sport environments carry distinct demands, schedules, and expectations, which likely contributed to the mixed findings. Additionally, none of the included studies directly assessed behavioural sleep hygiene using validated sleep hygiene instruments. Consequently, this review synthesized evidence based on sleep characteristics and sleep-related outcomes that may reflect, but do not directly measure, sleep hygiene practices. Despite these limitations, the studies provide preliminary insight into how sleep hygiene and sport participation are associated among middle childhood girls.

## Implications

The findings of this rapid review have important implications for research, practice, and parental decision-making. First, the variability in sleep indicators across studies highlights the need for more consistent and comprehensive measurement of sleep hygiene in youth girls sport research. Future studies should incorporate validated, multidimensional sleep hygiene tools alongside objective sleep measures whenever possible to better capture the range of behaviours that influence girls' sleep. Examining these relationships during middle childhood may be particularly important for supporting long-term sport participation and healthy behavioural development among girls before adolescence.

Insights from this review will directly inform the development of a parental educational toolkit designed to support parents in making informed decisions about their daughters' sport involvement and sleep hygiene practices. For parents and caregivers, these findings highlight the importance of monitoring sleep patterns alongside sport involvement, particularly when children participate in specialized or high-volume training environments. Parents may benefit from education regarding consistent bedtime routines, adequate sleep duration, recovery needs, and balancing sleep health with sport schedules. Supporting healthy sleep behaviours may represent one strategy for promoting positive sport participation experiences and sustained involvement among girls. The toolkit will aim to provide practical, evidence-informed guidance to help parents support healthy sleep routines while fostering positive and sustainable sport participation experiences.

## References

Biggins, M., Purtill, H., Fowler, P., Bender, A., Sullivan, K. O., Samuels, C., & Cahalan, R. (2019). Sleep in elite multi-sport athletes: Implications for athlete health and wellbeing. *Physical Therapy in Sport*, 39, 136–142. https://doi.org/10.1016/j.ptsp.2019.07.006

Blackwell, C. K., Hartstein, L. E., Elliott, A. J., Forrest, C. B., Ganiban, J., Hunt, K. J., Camargo, C. A., & LeBourgeois, M. K. (2020). Better sleep, better life? How sleep quality influences children's life satisfaction. *Quality of Life Research, 29(9)*, 2465–2474. https://doi.org/10.1007/s11136-020-02491-9

Brand, S., Gerber, M., Kalak, N., Kirov, R., Lemola, S., Clough, P. J., ... & Holsboer-Trachsler, E. (2014). Adolescents with greater mental toughness show higher sleep efficiency, more deep sleep and fewer awakenings after sleep onset. *Journal of Adolescent Health*, 54(1), 109-113.

Bruce, E. S., Lunt, L., & McDonagh, J. E. (2017). Sleep in adolescents and young adults. *Clinical Medicine (London, England), 17(5)*, 424–428. https://doi.org/10.7861/clinmedicine.17-5-424

Campbell, M., McKenzie, J. E., Sowden, A., Katikireddi, S. V., Brennan, S. E., Ellis, S., Hartmann-Boyce, J., Ryan, R., Shepperd, S., Thomas, J., Welch, V., & Thomson, H. (2020). Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline. *BMJ,* l6890. https://doi.org/10.1136/bmj.l6890

Chen, C., Weyland, S., Fritsch, J., Woll, A., Niessner, C., Burchartz, A., Schmidt, S. C. E., & Jekauc, D. (2021). A Short Version of the Physical Activity Enjoyment Scale: Development and Psychometric Properties. *International Journal of Environmental Research and Public Health*, *18*(21), 11035-. https://doi.org/10.3390/ijerph182111035

Chandrasekaran, B., Fernandes, S., & Davis, F. (2020). Science of sleep and sports performance a scoping review. *Science & Sports*, 35(1), 3-11.

Deelen, I., Ettema, D., & Kamphuis, C. B. M. (2018). Sports participation in sport clubs, gyms or public spaces: How users of different sports settings differ in their motivations, goals, and sports frequency. *PloS One*, *13*(10), e0205198–e0205198. https://doi.org/10.1371/journal.pone.0205198

De Pasquale, C., El Kazzi, M., Sutherland, K., Shriane, A. E., Vincent, G. E., Cistulli, P. A., & Bin, Y. S. (2024). Sleep hygiene – What do we mean? A bibliographic review. *Sleep Medicine Reviews*, *75*, Article 101930. https://doi.org/10.1016/j.smrv.2024.101930

Dobbins, M., Neil-Sztramko, S. E., & Caldwell, H. (2021). School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18. *Cochrane Database of Systematic Reviews*, 2021(9), CD007651. https://doi.org/10.1002/14651858.CD007651.pub3

Fältström, A., Skillgate, E., Weiss, N., Källberg, H., Lyberg, V., Waldén, M., Hägglund, M., Asker, M., & Tranaeus, U. (2022). Lifestyle characteristics in adolescent female football players: data from the Karolinska football Injury Cohort. *BMC Sports Science, Medicine & Rehabilitation*, *14*(1), 212–212. https://doi.org/10.1186/s13102-022-00603-1

Fonseca, A. P. L. M., de Azevedo, C. V. M., & Santos, R. M. R. (2021). Sleep and health-related physical fitness in children and adolescents: a systematic review. *Sleep Science*, 14(04), 357-365.

Ganann, R., Ciliska, D., & Thomas, H. (2010). Expediting systematic reviews: methods and implications of rapid reviews. Implementation science: IS, 5, 56. https://doi.org/10.1186/1748-5908-5-56

Griffith, J. M., Clark, H. M., Haraden, D. A., Young, J. F., & Hankin, B. L. (2021). Affective Development from Middle Childhood to Late Adolescence: Trajectories of Mean-Level Change in Negative and Positive Affect. *Journal of Youth and Adolescence*, 50(8), 1550–1563. https://doi.org/10.1007/s10964-021-01425-z

Irish, L. A., Kline, C. E., Gunn, H. E., Buysse, D. J., & Hall, M. H. (2015). The role of sleep hygiene in promoting public health: A review of empirical evidence. *Sleep Medicine Reviews*, 22, 23–36. https://doi.org/10.1016/j.smrv.2014.10.001

Kredlow, M. A., Capozzoli, M. C., Hearon, B. A., Calkins, A. W., & Otto, M. W. (2015). The effects of physical activity on sleep: a meta-analytic review. *Journal of behavioral medicine,* 38(3), 427-449.

Kosti, R. I., Tsiampalis, T., Kouvari, M., Gketsios, I., Kanellopoulou, A., Notara, V., ... & Panagiotakos, D. B. (2023). Clustering of activity-related behaviors in relation to self-reported causes of stress among pre-adolescents: results from a national epidemiological study. *Life, 13*(3), 622.

Lang, C., Kalak, N., Brand, S., Holsboer-Trachsler, E., Puehse, U., & Gerber, M. (2016). The relationship between physical activity and sleep from mid adolescence to early adulthood. A systematic review of methodological approaches and meta-analysis. *Sleep medicine reviews*, 28, 32-45.

Larrinaga-Undabarrena, A., Río, X., Sáez, I., Angulo-Garay, G., Aguirre-Betolaza, A. M., Albisua, N., Martínez de Lahidalga Aguirre, G., Sánchez Isla, J. R., García, N., Urbano, M., Guerra-Balic, M., Fernández, J. R., & Coca, A. (2023). Physical Activity Levels and Sleep in Schoolchildren (6-17) with and without School Sport. *International Journal of Environmental Research and Public Health*, *20*(2), 1263-. https://doi.org/10.3390/ijerph20021263

Lagisz, M., Vasilakopoulou, K., Bridge, C., Santamouris, M., & Nakagawa, S. (2022). Rapid systematic reviews for synthesizing research on built environment. *Environmental Development*, 43, 100730.

Mah, V. K., & Ford-Jones, E. L. (2012). Spotlight on middle childhood: Rejuvenating the 'forgotten years'. *Paediatrics & child health*, 17(2), 81-83.

Mastin, D. F., Bryson, J., & Corwyn, R. (2006). Assessment of sleep hygiene using the Sleep Hygiene Index. *Journal of behavioral medicine*, 29(3), 223-227.

Meisel, P. L., DiFiori, J. P., Côté, J., Nguyen, J. T., Brenner, J. S., Malina, R. M., Ryan, E., & Güllich, A. (2022). Age of Early Specialization, Competitive Volume, Injury, and

Sleep Habits in Youth Sport: A Preliminary Study of US Youth Basketball. *Sports Health*, 14(1), 30–44. https://doi.org/10.1177/19417381211056301.

Milewski, M. D., Skaggs, D. L., Bishop, G. A., Pace, J. L., Ibrahim, D. A., Wren, T. A., & Barzdukas, A. (2014). Chronic lack of sleep is associated with increased sports injuries in adolescent athletes. *Journal of pediatric orthopedics*, 34(2), 129–133. https://doi.org/10.1097/BPO.0000000000000151

Miller, L., Dockrill, M., Corkum, P. V., Kirk, S. F. L., & Stone, M. (2024). Associations of objectively measured physical activity and sleep in preschoolers aged 3 to 6 years. *Frontiers in Sleep*, 3. https://doi.org/10.3389/frsle.2024.1329774.

Mohammed S., Barakat, C., & Stanyon, W. (2020). “Examining Constraints to Sport Participation among Immigrant Adolescent Girls who reside in the Greater Toronto Area”, *Arch Health Sci*; 4(1): 1-13.

O’Donnell, S., & Driller, M. W. (2017). Sleep-hygiene education improves sleep indices in elite female athletes. *International Journal of Exercise Scienc*e, 10(4), 522–530. https://doi.org/10.70252/DNOL2901

Ophoff, D., Slaats, M. A., Boudewyns, A., Glazemakers, I., Van Hoorenbeeck, K., & Verhulst, S. L. (2018). Sleep disorders during childhood: a practical review. *European Journal of Pediatrics*, *177*(5), 641–648. https://doi.org/10.1007/s00431-018-3116-z

Ordway, M. R., Logan, S., & Sutton, E. H. (2022). Sleep deficiency in young children. *Clinics in chest medicine*, 43(2), 229-237.

Pagerols, M., Bosch, R., Prat, R., Pagespetit, È., Cilveti, R., Chaparro, N., Esteve, A., & Casas, M. (2023). The Sleep Disturbance Scale for Children: psychometric properties and prevalence of sleep disorders in Spanish children aged 6–16 years. *Journal of Sleep Research*, *32(4)*, e13871-n/a. https://doi.org/10.1111/jsr.13871.

Roberts, S. S. H., Teo, W.-P., & Warmington, S. A. (2019). Effects of training and competition on the sleep of elite athletes: a systematic review and meta-analysis. *British Journal of Sports Medicine*, *53*(8), 513–522. https://doi.org/10.1136/bjsports-2018-099322

Tricco, A. C., Langlois, E., Straus, S. E., & Organization, W. H. (2017). *Rapid reviews to strengthen health policy and systems: a practical guide.* World Health Organization.

Vitale, K. C., Owens, R., Hopkins, S. R., & Malhotra, A. (2019). Sleep Hygiene for Optimizing Recovery in Athletes: Review and Recommendations. *International journal of sports medicine*, 40(8), 535–543. https://doi.org/10.1055/a-0905-3103

Watson, A., Post, E., Biese, K., Kliethermes, S., Brooks, M. A., & Bell, D. (2021). Decreased Physical Activity and Sleep, Not Sport Specialization, Predict Illness in Middle School Athletes. *Sports Health*, 13(1), 25–30. https://doi.org/10.1177/1941738120927599

Westerbeek, H., & Eime, R. (2021). The Physical Activity and Sport Participation Framework-A Policy Model Toward Being Physically Active Across the Lifespan. *Frontiers in sports and active living, 3*, 608593. https://doi.org/10.3389/fspor.2021.608593.

Whiting, S., Buoncristiano, M., Gelius, P., Abu-Omar, K., Pattison, M., Hyska, J., Duleva, V., Musić Milanović, S., Zamrazilová, H., Hejgaard, T., Rasmussen, M., Nurk, E., Shengelia, L., Kelleher, C. C., Heinen, M. M., Spinelli, A., Nardone, P., Abildina, A., Abdrakhmanova, S., Breda, J. (2021). Physical Activity, Screen Time, and Sleep Duration of Children Aged 6–9 Years in 25 Countries: An Analysis within the WHO European Childhood Obesity Surveillance Initiative (COSI) 2015–2017. *Obesity Facts*, 14(1), 32–44. https://doi.org/10.1159/000511263

Yman, J., Helgadóttir, B., Kjellenberg, K., & Nyberg, G. (2023). Associations between organised sports participation, general health, stress, screen-time and sleep duration in adolescents. *Acta Paediatrica*, *112*(3), 452–459. https://doi.org/10.1111/apa.16556

**Appendix A. *S*earch Strategy used for the Rapid Review**

| Category | Terms |
|---|---|
| Middle childhood (ages 6-12) girls | "girl*" OR "female*" AND "p?ediatric*" OR "child*" OR "preadolescen*" OR "pre-adolescen*" OR "prepubescen*" OR "pre-pubescen*" OR "pubescen*" OR "school aged" OR "elementary school*" OR "middle childhood" OR "middle school*" OR "youth*" OR "young adult*" OR "school age*" OR "schoolchild*" OR "juvenile*" |
| Sleep Hygiene | "sleep.mp." OR "asleep" OR "oversleep*" OR "nap*" OR "doz*" OR "snooz*" OR "drows*" OR "slumber*" OR "slumbrous" OR "bed" OR "bedtime*" OR "bed time*" OR "restful" OR "wake" OR "waking" OR "wakefulness" OR "wide awake" OR "tired*" |
| Sports participation | sport* or athlet* or acrobat* or alpine* or archer* or badminton* or baseball* or basketball* or baseball* or biath* or bmx* or bobsle* or boccia* or boxing* or boxer* or bowling* or bowler* or broomball* or canoe* or cheerlead* or cricket* or crossfit* or cross-fit* or curling* or (cross adj1 country*) or cross-country or cycling* or cyclist* or diving* or diver* or equest* or fencing* or fencer* or (field adj1 hockey*) or (figure adj skat*) or football* or futsal* or golf* or goalball* or gymnast* or handball* or hockey* or judo* or karate* or kayak* or kickbox* or kick-box* or lacross* or (lawn adj1 bowl*) or luge* or (martial* adj2 art*) or muay thai or (mountain* adj1 bik*) or netball* or pentath* or racquet* or ringette* or (rock adj1 climb*) or rockclimb* or rower* or rowing* or rugby* or runner* or running* or sailing* or sailor* or soccer* or (ski adj1 jump*) or (ski adj1 mountain*) or skiing* or skier* or skateboard* or skating* or skater* or sledding* or snowboard* or softball* or speedskat* or speed-skat* or (speed* adj1 skat*) or squash* or swim* or surfing* or surfer* or taekwondo* or tennis* or (track adj field) or trampolin* or triath* or volleyball* or wakeboard* or (water adj1 polo*) or wrestling* or wrestler* or weightlight* or (weight adj lift*) or jiu jitsu* or jiu-jitsu* or jogging* or jogger* or kendo* or kung fu* or kung-fu* or mountaineer* or qigong* or (tai adj1 ji) or (tai adj1 chi*) or taiji* or taichi*) adj3 (participat* or involve* or join* or engage* or play)).mp |

## Appendix B. Risk of Bias (CASP) Tables

**Table C1.** *Risk of Bias Assessment of included Cohort Studies using the CASP Cohort Study Checklist*

| Author, Year | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Overall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Watson et al., 2021 | Yes | Some concern | Some concern | Some concern | Some concern | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Moderate |
| Falstrom, 2022 | Yes | Yes | Some concern | Some concern | No | No | Yes | Yes | Yes | Some concern | Yes | Yes | Moderate |

Q1. Did the study address a clearly focused issue?
Q2. Was the cohort recruited in an acceptable way?
Q3. Was the exposure accurately measured to minimize bias?
Q4. Was the outcome accurately measured to minimize bias?
Q5. Have the authors identified all important confounding factors?
Q6. Was the follow up of subject complete/long enough?
Q7. What are the results of the study?
Q8. How precise are the results?
Q9. Do you believe the results?
Q10. Can the results be applied to the local population?
Q11. Do the results of this study fit with other available evidence?
Q12. What are the implications of this study for practice?

**Table C2.** *Risk of Bias Assessment of included Cross-sectional Studies using the CASP Cross-Sectional Study Checklist*

| Author, Year | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Overall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Larrinaga-Undabarrena, 2023 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Low |

Q1. Did the study address a clearly focused issue?
Q2. Did the authors use an appropriate method to answer their question?
Q3. Were the subjects recruited in an acceptable way?
Q4. Were the measures accurately measured to reduce bias?
Q5. Were the data collected in a way that addressed the research issue?
Q6. Did the study have enough participants to minimize the play of chance?
Q7. How are the results presented and what is the main results?
Q8. Was the data analysis sufficiently rigorous?
Q9. Is there a clear statement of findings?
Q10. Can the results be applied to the local population?
Q11. How valuable is the research?

*Athens Journal of Sports - Volume 13, Issue 2, June 2026 – Pages 101-118*

# Nonlinear Optimization of Weekly Training Plans for Competitive Tennis Players

*By Dana Guzman Alcas[*] & Theodore Trafalis[±]*

*Training design in competitive tennis requires balancing performance improvement with injury prevention. Athletes must allocate limited weekly training time across multiple activities while managing nonlinear physiological responses. This study develops a constrained nonlinear optimization model that incorporates a concave performance function with diminishing returns and a convex injury-risk function representing overload effects. The model includes linear constraints on total training time, high-intensity workload, and minimum recovery. Optimality conditions are derived using the Karush–Kuhn–Tucker (KKT) framework, and numerical solutions are obtained using MATLAB's fmincon solver with a Sequential Quadratic Programming (SQP) algorithm. The results show that optimal training allocations balance technical drills, moderate high-intensity work, and sufficient recovery. The total weekly time constraint is consistently binding, while recovery often exceeds its minimum requirement. Sensitivity analysis demonstrates that increasing performance emphasis leads to higher high-intensity training and reduced recovery. It is concluded that nonlinear optimization provides a structured framework for weekly training design in tennis. The model highlights the importance of balancing performance gains and injury risk while respecting realistic training constraints.*

**Keywords**: *Training Load Optimization, Athlete Workload Management, Injury Risk Modeling, Performance Optimization, Tennis Training, Recovery Optimization.*

## Introduction

Training design in competitive sports requires balancing performance improvement with injury prevention. In tennis, athletes must distribute limited weekly training time across multiple activities, including match play, technical drills, strength training, conditioning, and recovery. Each of these components contributes differently to performance outcomes and physiological stress, creating a complex decision-making problem for athletes and coaches. Longitudinal athlete monitoring studies have shown that training volume and workload management significantly influence performance adaptation and fatigue accumulation (Rishiraj & Niven, 2018). Mathematical and analytical approaches have increasingly been applied to sports performance evaluation and decision-making. It has also been applied in other sport contexts such as football performance evaluation and team contribution analysis (Leela et al., 2023).

The relationship between training load and performance is inherently nonlinear. Performance improvements typically exhibit diminishing returns, where initial training produces substantial gains, but additional workload yields

[*]Graduate Student, School of Industrial and Systems Engineering, The University of Oklahoma, USA.
[±]Professor, School of Industrial and Systems Engineering, The University of Oklahoma, USA.

progressively smaller benefits. At the same time, injury risk increases at an accelerating rate as training intensity and volume rise, particularly when high-intensity sessions are excessive or insufficient recovery is provided (Kreher & Schwartz, 2012). Recovery activities play a critical role in mitigating fatigue and reducing injury risk, further complicating the allocation of training time.

Because of these competing effects, designing an effective weekly training schedule requires balancing multiple objectives under practical constraints. Athletes operate within limited time availability while needing to maintain sufficient recovery and avoid excessive workload. These constraints make it difficult to determine an optimal distribution of training activities using intuition alone. This study addresses this problem by developing a mathematical framework for allocating weekly training time across different activities. The model captures the nonlinear relationship between performance and workload, incorporates injury risk considerations, and includes realistic constraints on total training time, high-intensity training, and recovery. The objective is to identify training allocations that achieve a balance between performance improvement and injury prevention.

## Problem Description and Assumptions

### *Weekly Training Components/Variables*

A weekly training plan for a competitive tennis player is represented using five primary activity categories: high-intensity on-court training ($x_1$), low-intensity technical drills ($x_2$), strength training ($x_3$), conditioning ($x_4$), and recovery ($x_5$). Each of these components contributes differently to performance development and physiological stress.

High-intensity on-court training, which includes match play and competitive drills, plays a critical role in developing tactical awareness and match readiness. However, it also imposes significant physical and mechanical stress on the athlete (Deconstructing Stigma, 2025). Racquet sports require balancing technical skill development with physical conditioning demands that influence competitive performance (Layton & DeBeliso, 2017). Low-intensity technical drills contribute to skill refinement with relatively lower injury risk. Strength training and conditioning improve physical capacity and resilience but can contribute to fatigue when performed excessively. Recovery activities, such as mobility work and therapeutic interventions, are essential for reducing accumulated fatigue and supporting adaptation (Kreher & Schwartz, 2012). Athletic adaptation processes are inherently nonlinear and depend on the interaction between workload and physiological response (Venkata, 2014).

All five variables are continuous and nonnegative:

$$x_i \geq 0, \quad i = 1,2,3,4,5$$

Usage of hours is consistent with how coaches plan workloads. Later, for narrative interpretation, these hours can be discussed as approximate "days or sessions" of training (e.g., 3 hours of recovery aligning with about one recovery day).

*Modeling Assumptions*

Recent sports analytics studies have demonstrated the usefulness of quantitative modeling frameworks for evaluating complex athletic systems and performance interactions (Leela et al., 2024). To keep the model presented here tractable while still realistic, the following assumptions are made:

1. Weekly horizon and steady state. The schedule is optimized over one representative week. Interactions across multiple weeks (e.g., tournament cycles) are not modeled here.
2. Separable training effects. Performance benefit and injury risk are represented as additive contributions from each activity type. This assumes marginal effects depend mainly on the hours in that activity.
3. Smooth nonlinear responses. Performance gains and risk changes vary smoothly with hours, meaning small hour changes do not cause discontinuous jumps in outcomes.
4. Fixed parameters. Relative weights for performance benefit and injury risk are treated as constant during the week, reflecting a stable training philosophy during that planning period.
5. No discrete scheduling limits. The model does not explicitly enforce "integer days." Instead, hours are optimized continuously, then interpreted in practice.

These assumptions allow the model to capture key training dynamics while remaining mathematically manageable.

*Constraints*

Three main linear constraints structured the planning problem:

1. Weekly training budget (total hours limit). The total training time is limited by the athlete's available schedule and physiological capacity

$$x_1 + x_2 + x_3 + x_4 + x_5 \leq T_{max}$$

This represents time availability due to class, travel, injury management, or fatigue tolerance.

2. Cap on high-intensity on-court load.

$$x_1 \leq H_{max}$$

High-intensity match-like training is the most stressful component. Even elite athletes typically cannot exceed a certain weekly volume without risk of overload (Deconstructing Stigma, 2025).

*Minimum recovery requirement.*

$$x_5 \geq R_{min}$$

Recovery is treated as a mandatory workload; without an enforced minimum, the optimizer might push recovery unrealistically low to chase performance.

All constraints are written in the nonlinear-programming convention $g_i(x) \leq 0$, which is required for inequality-constrained NLP and MATLAB *fmincon* (Hu, 2018). All decision variables are constrained to be nonnegative, reflecting that training time cannot be negative.

**Parameter Choices**

The model parameters are selected to reflect realistic weekly training volumes for competitive tennis players. A total weekly training limit of 18 hours is assumed, along with a maximum of 8 hours of high-intensity training. The minimum recovery requirement is set at 3 hours per week under baseline conditions (UCHealth, 2025), with higher values considered in sensitivity. Relative weights are assigned to reflect the importance of different training activities in contributing to performance and injury risk. High-intensity training is associated with both strong performance benefits and elevated injury risk, while recovery contributes primarily to reducing fatigue and mitigating injury risk (Kreher & Schwartz, 2012).

Baseline constraints reflect common competitive weekly volume:

- $T_{max} = 18\ hours/week.$
- $H_{max} = 8\ hours/week.$
- $R_{min} = 3\ hours/week\ (\approx one\ recovery\ day)$

A second, safer recovery scenario uses:

- $R_{min} = 5\ hours/week\ (\approx two\ recovery\ days)$

Relative weights in the objective are chosen so that on-court time contributes strongly to performance, while overload in high-intensity, conditioning, and strength contributes strongly to injury risk.

The Model parameters are given in Table 1. Parameters were selected to be realistic for a competitive player and to illustrate the nonlinear tradeoff structure of the model. The weekly time budget $T_{max} = 18$ hours and high-intensity cap $H_{max} = 8$ hours reflect typical feasible training volume, while recovery minimum $R_{min}$ was tested at both baseline (3 hours/week) and safer (5 hours/week) policy levels. Performance weights $p_i$ emphasize the higher competitive value of on-court work, whereas quadratic risk penalties $\beta_1, \beta_3, \beta_4$ discourage overload in high-stress categories. Sensitivity experiments varied $\alpha$ to represent conservative ($\alpha = 0.5$), balanced ($\alpha = 1.0$), and aggressive ($\alpha = 2.0$) coaching priorities.

**Table 1.** *Model Parameters Used in Numerical Experiments*

| Symbol/name | Value(s) used | Units | Meaning/role in model |
|---|---|---|---|
| $T_{max}$ | 18 | hours/week | Maximum total weekly training time (time-budget constraint) |
| $H_{max}$ | 8 | hours/week | Maximum high-intensity on-court hours (cap on $x_1$) |
| $R_{min}$ | 3(baseline), 5(safer case) | hours/week | Minimum required weekly recovery volume (lower bound on $x_5$) |
| $\alpha$ | 0.5, 1.0, 2.0 | - | Risk-performance tradeoff weight. Smaller = more risk-averse; larger = more performance-driven. |
| $p = [p_1, p_2, p_3, p_4, p_5]$ | [4, 2.5, 1.5, 1.5, 1.0] | - | Performance benefit weights for each training category in $P(x) = \sum p_i ln(1 + x_i)$. |
| $\beta_1$ | 0.08 | - | Quadratic risk weight for high-intensity on-court training $x^2{}_1$. |
| $\beta_3$ | 0.08 | - | Quadratic risk weight for strength training $x^2{}_3$. |
| $\beta_4$ | 0.08 | - | Quadratic risk weight for conditioning training $x^2{}_4$. |
| $\rho$ | 0.6 | - | Recovery benefit weight in risk term $-\rho ln(1 + x_5)$. |

## Mathematical Model

### *Performance Benefit*

Performance improvements from training show diminishing returns. A smooth concave form is:

$$P(x) = \sum_{i=1}^{5} p_i ln(1 + x_i), \text{ with } p_i > 0$$

Marginal benefits:

$$\frac{\partial P}{\partial x_i} = \frac{p_i}{1+x_i} > 0, \quad \frac{\partial^2 P}{\partial x^2{}_i} = -\frac{p_i}{(1+x_i)^2} < 0$$

This formulation ensures that each additional unit of training contributes less marginal improvement (Molloy et al., 2012).

*Injury Risk*

Injury risk increases more than linearly with high-stress training, while recovery reduces risk with diminishing returns. Injury risk is modeled as a convex funcion:

$$I(x) = \beta_1 x^2{}_1 + \beta_3 x^2{}_3 + \beta_4 x^2{}_4 - \rho ln(1 + x_5)$$

with $\beta_1, \beta_3, \beta_4, \rho \; > 0$.

Here, quadratic terms capture the rapid increase in risk for high workloads, while recovery reduces risk (UCHealth, 2025).

*Weighted Single-Objective Formulation*

The weighted objective is

$$F(x) = I(x) - \alpha P(x)$$

where $\alpha > 0$ controls the trade-off (larger $\alpha$ emphasizes performance relative to risk). The optimization problem is:

$$min_x \quad F(x)$$

$$\begin{aligned} s.t. \quad & g_1(x) = x_1 + x_2 + x_3 + x_4 + x_5 - T_{max} \leq 0 \\ & g_2(x) = x_1 - H_{max} \leq 0 \\ & g_3(x) = R_{min} - x_5 \leq 0 \\ & g_{3+i}(x) = -x_i \leq 0, \quad i = 1,2,3,4 \end{aligned}$$

Nonnegativity is enforced for $x_1 - x_4$; $x_5$ is already bounded by the recovery minimum.

This is a nonlinear programming problem with inequality constraints.

*Gradient Expressions (needed for KKT interpretation)*

The partial derivatives of the objective are:

$$\frac{\partial F}{\partial x_1} = 2\beta_1 x_1 - \alpha \frac{p_1}{1 + x_1}$$

$$\frac{\partial F}{\partial x_2} = -\alpha \frac{p_2}{1 + x_2}$$

$$\frac{\partial F}{\partial x_3} = 2\beta_3 x_3 - \alpha \frac{p_3}{1 + x_3}$$

$$\frac{\partial F}{\partial x_4} = 2\beta_4 x_4 - \alpha \frac{p_4}{1 + x_4}$$

$$\frac{\partial F}{\partial x_5} = -\rho \frac{1}{1 + x_5} - \alpha \frac{p_5}{1 + x_5}$$

These derivatives show explicitly how quadratic risk growth competes against diminishing performance returns.

*Convexity/Nonconvexity Discussion*

- The performance function is concave. Therefore, the term involving the performance function with the negative sign becomes convex.
- The risk term involving squares is convex since betas must be positive. If betas were negative, the function would become concave, meaning that the more you train, the lower the risk becomes at an accelerating rate. This contradicts the biological principle of "overuse injuries" and the physical reality of fatigue.

Since the negative log is convex the injury risk function is also convex.

**Constrained Optimality Theory (Lagrangian & KKT)**

For inequality-constrained problems, the Lagrangian is formed using multipliers $\lambda_i \geq 0$

$$L(x, \lambda) = F(x) + \sum_{i=1}^{7} \lambda_i g_i(x)$$

If LICQ holds, the Karush-Kuhn-Tucker conditions are necessary for a local minimum. The optimal schedule $x^*$ and multipliers $\lambda^*$ satisfy:

1. Stationarity: $\nabla_x L(x^*, \lambda^*) = 0$
2. Primal feasibility: $g(x^*) \leq 0$
3. Dual feasibility: $\lambda^* \geq 0$
4. Complementary slackness: $\lambda^* \boldsymbol{g}(\boldsymbol{x}^*) = \boldsymbol{0}$

Complementary slackness implies two cases for each inequality constraint: if $g(x^*) < 0$(inactive), then $\lambda^* = 0$; if $g(x^*) = 0$ (active), then $\lambda^*$ may be positive.

Interpretation for this model.

- The total-hours constraint $g_1$ is expected to be active in most cases (players usually use all available hours).
- The recovery minimum $g_3$ becomes active in aggressive performance settings.
- The high-intensity cap $g_2$ becomes active only if the performance benefit outweighs the risk.

These conditions allow interpretation of constraint activity and optimal allocation behavior.

**Numerical Solution Procedure (MATLAB Implementation)**

The training-plan optimization problem above is a smooth nonlinear program with inequality constraints. To compute numerical solutions, the problem was implemented and solved in MATLAB using ***fmincon***, which is the standard solver for constrained nonlinear optimization in the MATLAB Optimization Toolbox. The general *fmincon* call follows the following formulation:

$$[x_{opt}, f_{opt}] = fmincon(fun, x_0, A, b, A_{eq}, b_{eq}, LB, UB, nonlcon)$$

where ***fun*** evaluates the objective function $F(x)$, and the remaining inputs represent constraints and bounds.
Here, $A_{eq}$ and $b_{eq}$ are empty since no equality constraints are used.

*Objective Function Definition*

The objective function $F(x) = I(x) - \alpha P(x)$ was coded in a separate MATLAB function file (***fun.m***). This file returns the numerical value $F(x)$ for any candidate's weekly schedule $x$. This function file is stored in the same directory as the main script.

*Constraint Representation*

All inequality constraints were written in the standard form $g(x) \leq 0$, as required for nonlinear programming in MATLAB.

- Weekly training budget: $x_1 + x_2 + x_3 + x_4 + x_5 \leq T_{max}$
- High-intensity cap: $x_1 \leq H_{max}$
- Minimum recovery: $x_5 \geq R_{min}$, rewritten as $-x_5 \leq -R_{min}$

Nonnegativity constraints $x_i \geq 0$ were handled through the lower–bound $LB$. These inputs match the solver structure outlined in the computational optimization notes, where $A, b$ represent linear inequalities and $LB, UB$ specify variable bounds.

Because the constraints are linear, no nonlinear constraint file was needed (***nonlcon* = *[]***).

*Constraint Implementation*

In this project, the planning constraints are linear, so they were placed directly into the matrices $A$ and $b$:

- $\boldsymbol{A} * \boldsymbol{x} \leq \boldsymbol{b}$ for total hours, high-intensity cap, and recovery minimum (rewritten as $-x_5 \leq -R_{min}$).
- $LB$ for nonnegativity and recovery lower bound.

*Solver Options and Algorithm Choice*

Solver settings were controlled using ***optimset***, as ***optimset*** is used to select algorithms and display/termination options for ***fmincon***.

A feasible initial guess $x_0$ was provided to start the iterations. The solver termination was based on MATLAB's default feasibility and optimality tolerances unless otherwise stated.

## Sensitivity Analysis Runs

After computing a baseline optimal schedule, additional runs were performed to study how the solution changes under different coaching philosophies and recovery requirements. Two main sensitivity experiments were planned:

1. Risk–performance tradeoff: vary $\alpha$ to generate conservative versus aggressive training plans.
2. Recovery requirement: compare baseline $R_{min} = 3$ hours/week (≈ one recovery day) to a safer scenario $R_{min} = 5$ hours/week (≈ two recovery days).

These experiments demonstrate how constraints and tradeoff weights affect the optimal allocation.

## Computational Results

This section summarizes the numerical solutions obtained in MATLAB using ***fmincon*** with the SQP algorithm. The solver setup follows the standard course formulation for constrained nonlinear programs, with linear inequalities implemented through $A, b$ and bounds through $LB, UB$.

*Baseline Optimal Schedule*

Under the baseline constraints:

$T_{max} = 18\ hours/week,$

$$H_{max} = 8\ hours/week, \quad R_{min} = 3\ hours/week,$$

MATLAB returned the following optimal weekly training plan:

$$.x_{opt} = [x_1,\ x_2,\ x_3, x_4, x_5] = [3.511, 7.0458, 1.6269, 1.6269, 4.1493].$$

The corresponding minimum objective value was:

$$f_{opt} = -15.3616$$

A clearer presentation of the decision variables is shown in Table 2.

**Table 2.** *Results under Baseline Constraints*

| Component | Meaning | Optimal hours/week |
|---|---|---|
| $x_1$ | High-intensity on court drills + match play | 3.511 |
| $x_2$ | Low-intensity technical drills | 7.046 |
| $x_3$ | Strenght training | 1.627 |
| $x_4$ | Conditioning/cardio | 1.627 |
| $x_5$ | Recovery work | 4.149 |
| Total | | $\approx 18.00$ |

The optimizer used the full-time budget (18 hours), showing that the weekly training-hours constraint dominates the solution. The largest allocation is to technical drills ($x_2$), which provides a strong performance benefit without a quadratic risk penalty, while higher-stress categories remain moderate due to convex risk growth. Recovery time is above its minimum, indicating it is valuable even when not forced by constraints.

*KKT Multiplier Interpretation (Constraint Activity)*

To interpret constraint activity, the Lagrange multipliers reported by MATLAB were examined. The inequality multipliers were:

$$\lambda_{ineqlin} = [0.3107, 0, 0]^T \text{ , as a 3x1 vector.}$$

These correspond to the linear constraints in the order they were defined in $A, b$:

(1) total weekly hours, (2) high-intensity cap, and (3) recovery minimum.

Because $\lambda_1 = 0.3107$, the total-time budget constraint is active/binding. Since $\lambda_2 = \lambda_3 = 0$, the high-intensity cap and recovery minimum are inactive at the optimum. This matches complementary slackness: inactive constraints have zero multipliers, while active constraints may have positive multipliers.

Lower-bound multipliers were all zero:

$$\lambda_{lower} = [0, 0, 0, 0, 0],$$

confirming that no variable is stuck at its lower bound; each training component remains strictly positive in the optimum.

*Sensitivity Study A: Varying Risk–Performance Tradeoff $\alpha$*

To understand how risk tolerance changes the optimal schedule, $\alpha$ should be varied while keeping all constraints fixed. This provides conservative vs. aggressive weekly plans (Table 3).

**Table 3.** *Results under different $\alpha$*

| $\alpha$ | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ | Total |
|---|---|---|---|---|---|---|
| 0.5 (risk first) | 2.549 | 7.029 | 1.179 | 1.179 | 6.065 | 18.00 |
| 1.0 (baseline) | 3.511 | 7.046 | 1.627 | 1.627 | 4.149 | 18.00 |
| 2.0 (performance first) | 4.633 | 6.363 | 2.002 | 2.002 | 3.000 | 18.00 |

Interpretation:

As the tradeoff weight $\alpha$ increases, the optimizer prioritizes performance over injury risk. The high-intensity and strength components $(x_1, x_3, x_4)$ increase steadily, while recovery $(x_5)$ decreases until it reaches its lower bound at $\alpha = 2$. Conversely, when $\alpha = 0.5$, recovery time expands to over six hours, and high-stress components are reduced, producing a safer but less performance-driven training plan. Across all scenarios, the total time constraint remains active, confirming that weekly training hours are fully utilized.

*Sensitivity Study B: Increasing the Recovery Minimum*

A second experiment evaluates a stricter recovery policy as shown in Table 4.

**Table 4.** *Results under different recovery times*

| Scenario | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ |
|---|---|---|---|---|---|
| Baseline $R_{min} = 3, \alpha = 1.0$ | 3.511 | 7.046 | 1.627 | 1.627 | 4.149 |
| Safer $R_{min} = 5, \alpha = 1.0$ | 3.4762 | 6.4093 | 1.5572 | 1.5572 | 5.0000 |

Interpretation:

Increasing the recovery minimum to 5 hours forces $x_5$ to bind at its lower limit and shift time mainly away from technical and high-stress categories while preserving the full weekly budget.

*Practical Interpretation (Hours → Days)*

Although decision variables are optimized in hours, recovery can be interpreted in days for narrative clarity. The baseline solution gives:

- $x_5 \approx 4.15\ hours/week$ ≈ 1-2 structured recovery days/week (depending on daily recovery duration).

## Discussion

The baseline optimum is realistic because of the nonlinear structure in the objective. The performance term is concave $(ln(1 + x_i))$, so marginal performance benefits decrease as a category grows. This prevents the optimizer from allocating nearly all 18 hours into a single component. In contrast, injury-risk penalties are convex and quadratic for $x_1, x_3, x_4$, meaning risk accelerates rapidly after moderate volume. As a result, high-stress categories are kept controlled even though they positively influence performance.

The KKT multipliers provide meaningful interpretation. The positive multiplier on the total weekly-hours constraint indicates that time availability is the main limiting resource: if the athlete had a larger weekly budget, the objective value could improve. The zero multipliers for both the high-intensity cap and recovery minimum imply that those policies do not bind under baseline preferences — the model's natural risk penalty already keeps high-intensity volume low, and recovery is worthwhile enough to exceed its minimum without being forced.

Once the sensitivity studies are inserted, this section should emphasize how optimal plans shift based on risk tolerance $(\alpha)$ and on stricter recovery policies. Together, these results show the model can function as a practical decision tool that lets a coach adjust training philosophy while maintaining mathematical consistency with nonlinear constrained optimality principles.

## Difficulties, Deviations, and Limitations

The main difficulties, deviations, and limitations for this project are:

1. Illustrative coefficients. The model was designed as a category (iii) project, which allows fictitious but realistic parameter values to demonstrate methodology rather than relying on full athlete-specific calibration.

2. Single-week horizon. The optimization focuses on one representative week and does not explicitly model multi-week fatigue accumulation, tapering cycles, or tournament scheduling.
3. Separable objective terms. Performance and risk are modeled as additive effects of each activity category. Interaction effects (e.g., strength improving tolerance to match play) are not directly included.
4. Local optimality. Because the objective may be nonconvex depending on $\alpha$, ***fmincon*** guarantees a local optimum. Multiple feasible starting points help confirm stability, but global optimality is not proven.
5. Continuous hours rather than discrete schedules. The solution provides hour allocations, which must still be translated into a day-by-day weekly microcycle by a coach.

These limitations define where the model is most appropriate and motivate future improvements.

## Conclusions and Future Work

This project formulated and solved a constrained nonlinear optimization model for weekly tennis training allocation. The objective combined accelerating injury risk penalties and diminishing performance returns, while enforcing realistic weekly planning constraints. The KKT framework supported interpretation of active/inactive constraints, and MATLAB ***fmincon*** (SQP) provided a numerical optimum consistent with course computational optimization methods.

Key conclusions from the baseline results are:

1. The optimal plan uses the entire weekly time budget essentially, and the positive KKT multiplier confirms the total-hours constraint is binding.
2. High-intensity, strength, and conditioning are controlled naturally through nonlinear risk penalties, keeping the high-intensity cap inactive.
3. Recovery exceeds its minimum even without being forced, indicating recovery has strong value in reducing overall risk under baseline preferences.

Future work could extend the model by (a) Optimizing multi-week schedules with fatigue carryover; (b) Calibrating parameters using athlete monitoring data; (c) Adding interaction terms between categories; and (d) Comparing SQP with penalty, barrier, or evolutionary algorithms, discussed later in the course.

## References

Deconstructing Stigma. (2025, October 17). *Strength isn't just physical: Exploring athletes' mental health*. https://deconstructingstigma.org/guides/athlete-mh

Hu, B. (2018). *ECE490: Introduction to optimization (Lecture 17)*. University of Illinois Urbana-Champaign. https://binhu7.github.io/courses/ECE490/files/Lecture17.pdf

Kreher, J. B., & Schwartz, J. B. (2012). Overtraining syndrome: A practical guide. *Sports Health*, *4*(2), 128–138. https://doi.org/10.1177/1941738111434406

Layton, J. S., & DeBeliso, M. (2017). Is there a relationship between maximal grip strength and racquetball success? A pilot study. *Athens Journal of Sports*, *4*(2), 139–150. https://www.athensjournals.gr/sports/2017-4-2-4-Layton.pdf

Leela, J., Commisiong, D. M. G., & Rahaman, K. (2023). A mathematical analysis of team impact and individual player contribution in football. *Athens Journal of Sports*, *10*(4), 215–234. https://www.athensjournals.gr/sports/2023-10-4-2-Leela.pdf

Leela, J., Rahaman, K., & Comissiong, D. M. G. (2024). Analyzing the efficiency of passing networks in soccer. *Athens Journal of Sports*, *11*(1), 37–58. https://www.athensjournals.gr/sports/2024-11-1-3-Leela.pdf

Molloy, K., Moore, J. W., & Fletcher, P. C. (2012). Less is more: Latent learning is maximized by shorter training sessions. *Frontiers in Human Neuroscience*, *6*, 42. https://doi.org/10.3389/fnhum.2012.00042

Rishiraj, N., & Niven, B. (2018). Physical and performance changes in rugby union female student-athletes over 31- and 52-weeks. *Athens Journal of Sports*, *5*(3), 199–212. https://www.athensjournals.gr/sports/2018-5-3-2-Rishiraj.pdf

UCHealth. (2025, March 31). *Why rest and recovery is essential for athletes: Physiological and psychological well-being*. https://www.uchealth.org/today/rest-and-recovery-for-athletes-physiological-psychological-well-being/

Venkata, R. (2014). "Panoptic differential training: Bio-dynamics approach for sprint time trial cycling performance" – A critical perspective. *Athens Journal of Sports*, *1*(4). https://www.atiner.gr/journals/sports/2014-1-4-2-Venkata.pdf

## Appendices

### A. main.m code in MATLAB

**Image 1.** *main.m MATLAB code part 1*

```
main.m × | fun.m × | +
/MATLAB Drive/main.m
clear; clc; close all;

%% ----- Parameters (illustrative baseline) -----
Tmax = 18;      % total weekly hours limit
Hmax = 8;       % max high-intensity hours
Rmin = 3;       % min recovery hours (baseline)

alpha = 1.0;                    % tradeoff weight
p     = [4 2.5 1.5 1.5 1.0];    % performance weights
beta  = [0.08 0.08 0.08];       % risk weights for x1,x3,x4
rho   = 0.6;                    % recovery benefit weight

%% ----- Initial guess (must be feasible) -----
x0 = [4 6 2 2 4];   % sums to 18, x1<=8, x5>=3

%% ----- Linear inequality constraints A*x <= b -----
% (1) x1+x2+x3+x4+x5 <= Tmax
% (2) x1 <= Hmax
% (3) x5 >= Rmin  ->  -x5 <= -Rmin

A = [ 1 1 1 1 1;
      1 0 0 0 0;
      0 0 0 0 -1];

b = [Tmax;
     Hmax;
     -Rmin];

%% ----- No linear equalities -----
Aeq = [];
beq = [];

```

**Image 2.** *main.m MATLAB code part 2*

```
main.m × | fun.m × | +
/MATLAB Drive/main.m
b = [Tmax;
     Hmax;
     -Rmin];

%% ----- No linear equalities -----
Aeq = [];
beq = [];

%% ----- Bounds -----
LB = [0 0 0 0 Rmin];   % nonnegativity + recovery minimum
UB = [];               % no upper bounds besides A,b

%% ----- Options (course style) -----
opts = optimset('Display','iter','Algorithm','sqp');

%% ----- Solve -----
[xopt, fopt, exitflag, output, lambda] = ...
    fmincon(@(x) fun(x,alpha,p,beta,rho), x0, A, b, Aeq, beq, LB, UB, [], opts);

%% ----- Display results -----
disp('Optimal schedule xopt = [x1 x2 x3 x4 x5]:');
disp(xopt);

disp('Objective value fopt =');
disp(fopt);

disp('Total hours used =');
disp(sum(xopt));

disp('Lagrange multipliers (lambda) =');
disp(lambda);

```

## B. fun.m code in MATLAB

**Image 3.** *fun.m MATLAB code*

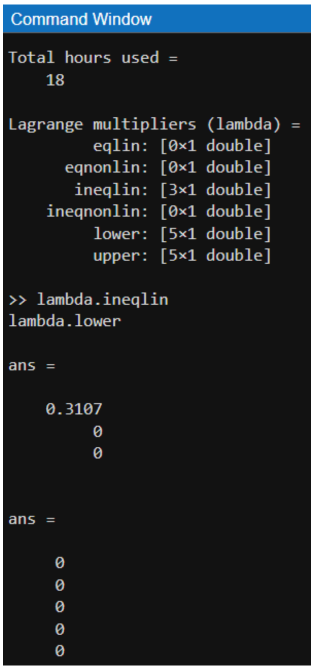
```
main.m ×   fun.m ×   +
/MATLAB Drive/fun.m

function f = fun(x, alpha, p, beta, rho)
% x = [x1 x2 x3 x4 x5] in hours/week

x1 = x(1);
x2 = x(2);
x3 = x(3);
x4 = x(4);
x5 = x(5);

% performance weights
p1 = p(1); p2 = p(2); p3 = p(3); p4 = p(4); p5 = p(5);

% risk weights
b1 = beta(1);  % for x1
b3 = beta(2);  % for x3
b4 = beta(3);  % for x4

% ----- Performance benefit (concave, diminishing returns) -----
P = p1*log(1+x1) + p2*log(1+x2) + p3*log(1+x3) + ...
    p4*log(1+x4) + p5*log(1+x5);

% ----- Injury risk (convex overload + recovery benefit) -----
I = b1*x1^2 + b3*x3^2 + b4*x4^2 - rho*log(1+x5);

% ----- Weighted objective to MINIMIZE -----
f = I - alpha*P;
end
```

## B. MATLAB outputs

**Image 4.** *main.m MATLAB outputs with alpha = 1.0 part 1*

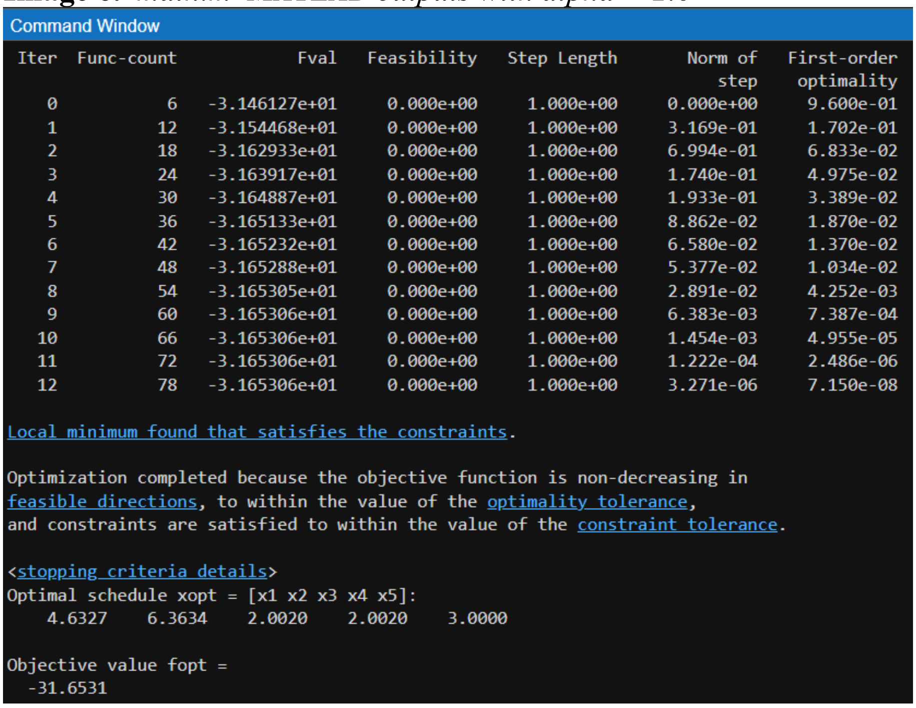
```
Command Window
 Iter  Func-count            Fval   Feasibility   Step Length       Norm of   First-order
                                                                       step    optimality
    0           6   -1.525346e+01     0.000e+00     1.000e+00     0.000e+00     3.571e-01
    1          12   -1.528445e+01     0.000e+00     1.000e+00     1.836e-01     1.118e-01
    2          18   -1.535445e+01     3.553e-15     1.000e+00     7.720e-01     3.460e-02
    3          24   -1.535705e+01     0.000e+00     1.000e+00     1.657e-01     1.586e-02
    4          30   -1.535758e+01     0.000e+00     1.000e+00     3.088e-02     1.516e-02
    5          36   -1.535984e+01     3.553e-15     1.000e+00     1.474e-01     9.777e-03
    6          42   -1.536131e+01     0.000e+00     1.000e+00     2.127e-01     9.127e-03
    7          48   -1.536149e+01     0.000e+00     1.000e+00     3.187e-02     6.472e-03
    8          54   -1.536163e+01     0.000e+00     1.000e+00     3.279e-02     1.197e-03
    9          60   -1.536163e+01     0.000e+00     1.000e+00     4.650e-03     1.737e-04
   10          66   -1.536163e+01     0.000e+00     1.000e+00     1.061e-03     1.149e-05
   11          72   -1.536163e+01     0.000e+00     1.000e+00     5.733e-05     1.144e-06
   12          78   -1.536163e+01     0.000e+00     1.000e+00     1.232e-05     5.877e-08

Local minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in
feasible directions, to within the value of the optimality tolerance,
and constraints are satisfied to within the value of the constraint tolerance.

<stopping criteria details>
Optimal schedule xopt = [x1 x2 x3 x4 x5]:
    3.5511     7.0458     1.6269     1.6269     4.1493

Objective value fopt =
  -15.3616
```

**Image 5.** *main.m 0MATLAB outputs with alpha = 1.0 part 2*



```
Command Window
Total hours used =
    18

Lagrange multipliers (lambda) =
         eqlin: [0×1 double]
      eqnonlin: [0×1 double]
       ineqlin: [3×1 double]
    ineqnonlin: [0×1 double]
         lower: [5×1 double]
         upper: [5×1 double]

>> lambda.ineqlin
lambda.lower

ans =

    0.3107
         0
         0


ans =

     0
     0
     0
     0
     0
```

**Image 6.** *main.m MATLAB outputs with alpha = 2.0*



```
Command Window
 Iter  Func-count            Fval   Feasibility   Step Length       Norm of   First-order
                                                                       step    optimality
    0           6   -3.146127e+01    0.000e+00     1.000e+00     0.000e+00     9.600e-01
    1          12   -3.154468e+01    0.000e+00     1.000e+00     3.169e-01     1.702e-01
    2          18   -3.162933e+01    0.000e+00     1.000e+00     6.994e-01     6.833e-02
    3          24   -3.163917e+01    0.000e+00     1.000e+00     1.740e-01     4.975e-02
    4          30   -3.164887e+01    0.000e+00     1.000e+00     1.933e-01     3.389e-02
    5          36   -3.165133e+01    0.000e+00     1.000e+00     8.862e-02     1.870e-02
    6          42   -3.165232e+01    0.000e+00     1.000e+00     6.580e-02     1.370e-02
    7          48   -3.165288e+01    0.000e+00     1.000e+00     5.377e-02     1.034e-02
    8          54   -3.165305e+01    0.000e+00     1.000e+00     2.891e-02     4.252e-03
    9          60   -3.165306e+01    0.000e+00     1.000e+00     6.383e-03     7.387e-04
   10          66   -3.165306e+01    0.000e+00     1.000e+00     1.454e-03     4.955e-05
   11          72   -3.165306e+01    0.000e+00     1.000e+00     1.222e-04     2.486e-06
   12          78   -3.165306e+01    0.000e+00     1.000e+00     3.271e-06     7.150e-08

Local minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in
feasible directions, to within the value of the optimality tolerance,
and constraints are satisfied to within the value of the constraint tolerance.

<stopping criteria details>
Optimal schedule xopt = [x1 x2 x3 x4 x5]:
    4.6327    6.3634    2.0020    2.0020    3.0000

Objective value fopt =
  -31.6531
```

**Image 7.** *main.m MATLAB outputs with alpha = 0.5*

```
Command Window
 Iter  Func-count            Fval   Feasibility   Step Length       Norm of   First-order
                                                                       step    optimality
    0           6   -7.149564e+00     0.000e+00     1.000e+00     0.000e+00     2.400e-01
    1          12   -7.287261e+00     0.000e+00     1.000e+00     3.842e-01     2.072e-01
    2          18   -7.653805e+00     0.000e+00     1.000e+00     1.680e+00     9.212e-02
    3          24   -7.696696e+00     0.000e+00     1.000e+00     7.541e-01     7.848e-02
    4          30   -7.704485e+00     0.000e+00     1.000e+00     1.096e-01     5.634e-02
    5          36   -7.711652e+00     0.000e+00     1.000e+00     2.285e-01     7.000e-03
    6          42   -7.711746e+00     0.000e+00     1.000e+00     1.239e-02     6.803e-03
    7          48   -7.712293e+00     0.000e+00     1.000e+00     6.768e-02     5.785e-03
    8          54   -7.713606e+00     0.000e+00     1.000e+00     3.038e-01     5.793e-03
    9          60   -7.713743e+00     3.553e-15     1.000e+00     6.353e-02     2.787e-03
   10          66   -7.713770e+00     0.000e+00     1.000e+00     2.348e-02     1.912e-04
   11          72   -7.713770e+00     0.000e+00     1.000e+00     2.366e-03     9.743e-06
   12          78   -7.713770e+00     0.000e+00     1.000e+00     3.139e-04     2.740e-07

Local minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in
feasible directions, to within the value of the optimality tolerance,
and constraints are satisfied to within the value of the constraint tolerance.

<stopping criteria details>
Optimal schedule xopt = [x1 x2 x3 x4 x5]:
    2.5490    7.0286    1.1786    1.1786    6.0652

Objective value fopt =
   -7.7138
```

**Image 8.** *main.m MATLAB outputs with* $R_{min} = 5$

```
Command Window
Initial point X0 is not between bounds LB and UB;
FMINCON shifted X0 to satisfy the bounds.
 Iter  Func-count            Fval   Feasibility   Step Length       Norm of   First-order
                                                                       step    optimality
    0           6   -1.554518e+01     1.000e+00     1.000e+00     0.000e+00     3.571e-01
    1          12   -1.530723e+01     0.000e+00     1.000e+00     5.250e-01     2.071e-01
    2          18   -1.531308e+01     0.000e+00     1.000e+00     8.002e-02     6.932e-02
    3          24   -1.532870e+01     0.000e+00     1.000e+00     3.480e-01     2.472e-02
    4          30   -1.533070e+01     0.000e+00     1.000e+00     1.702e-01     8.379e-03
    5          36   -1.533078e+01     0.000e+00     1.000e+00     1.173e-02     5.474e-03
    6          42   -1.533083e+01     0.000e+00     1.000e+00     1.623e-02     2.000e-04
    7          48   -1.533083e+01     0.000e+00     1.000e+00     7.148e-04     1.140e-05
    8          54   -1.533083e+01     0.000e+00     1.000e+00     5.325e-05     5.895e-08

Local minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in
feasible directions, to within the value of the optimality tolerance,
and constraints are satisfied to within the value of the constraint tolerance.

<stopping criteria details>
Optimal schedule xopt = [x1 x2 x3 x4 x5]:
    3.4762    6.4093    1.5572    1.5572    5.0000

Objective value fopt =
  -15.3308

Total hours used =
    18
```

# Volunteerism and the Olympic Games: From 1980 to 2024

*By Ioannis Karmas**, *George Karlis*± *& Nicos Kartakoullis*○

*This paper provides a descriptive review of volunteering at the Olympic Games from 1980 to 2024. Through the compilation of secondary data, the intent is to: (1) compare the number of volunteers from 1980 to 2024 while identifying trends and directions of Olympic volunteerism, and (2) present the limited existing data on demographics to understand the make-up of volunteers. The results indicate that: (1) a significant growth in the number of Summer and Winter Olympic Games volunteers since Lake Placid 1980, (2) a growing trend to increasing volunteer reliance for both the Summer and the Winter Olympic Games when comparing volunteer numbers pre and post 2000, (3) more women volunteer at the Summer Olympic Games and slightly more men volunteer at the Winter Olympic Games, (4) the highest number of Olympic Games volunteers come from the 16-35 age cohort, and, (5) both the Summer and Winter Olympic Games rely primarily on domestic sport volunteers while the Summer Olympic Games attracts more sport volunteer tourists than the Winter Olympic Games.*

**Keywords:** *volunteerism, Olympic Games, sport volunteers, sport volunteer tourists*

## Introduction

The role of volunteers at the Olympic Games is not just significant, it's unique. Former International Olympic Committee [IOC] President Jacques Rouge aptly described Olympic Games volunteers as 'true Olympians' and 'the unsung heroes' (IOC 2011). The IOC itself has consistently underscored the pivotal role of volunteers, stating that volunteers are the ones who 'make the Games' (IOC n.d.).

At the most recent Summer Olympic Games held in Paris in 2024, just like in past Olympic Games, the host Organizing Committee for the Olympic Games (OCOG), was mandated to recruit, train, and coordinate the volunteers and the volunteer services provided. Indeed, the OCOG's of the host city of each respective Olympic Games, Summer and Winter, have the colossal task of planning, organizing, directing, and controlling the large number of volunteers to ascertain that not only are the necessary services being provided accordingly, but also by instilling a philosophy of Olympism in volunteers. As Olympic Games volunteers are the first contact of encounter for guests, spectators, athletes, coaches, officials, and media, sufficient recruitment and training of these volunteers is of utmost importance (Karlis 2006).

Volunteering is serious business, particularly at mega-sports events such as the Olympic Games. Not only are volunteers' unsung heroes, but volunteers are also the

*PhD Candidate, School of Human Kinetics, University of Ottawa, Canada.
±Full Professor, School of Human Kinetics, University of Ottawa, Canada.
○Adjunct Professor, School of Human Kinetics, University of Ottawa, Canada and Full Professor, School of Business, University of Nicosia, Cyprus.

face of the Games. The successful implementation of the Olympic Games depends on the efforts of volunteers and the services that these volunteers provide. Interestingly, the Olympic Games volunteer movement as it appears today has not been around that long, first commencing during the Lake Placid Games in 1980 (Moreno, 1999). Thus, research on volunteerism at the Olympic Games is limited as this area of research is still quite young. Since 2000 however, researchers such as Karlis (2008) and Holmes at al., (2024) have called for more research to better understand volunteerism at the Olympic Games and its relevance and importance This paper aims to contribute to the limited research on volunteerism at the Olympic Games.

Using a descriptive review this paper presents a comparative overview of volunteering at the Olympic Games from 1980 to 2024. Through the compilation of secondary data, the intent is to: (1) compare the number of volunteers from 1980 to 2024 while identifying trends and directions of Olympic volunteerism, and (2) present the limited existing data on demographics to understand the make-up of volunteers. Specifically, the objectives of this paper are to:

1. Compare the number of volunteers at the Summer and Winter Olympic Games from 1980 to 2024.
2. Depict trends of volunteers at the Summer and Winter Olympic Games from 1980 to 2024.
3. Look at the demographics of age and gender of Olympic Games volunteers at the Summer and Winter Olympic Games from 1980 to 2024.
4. Identify and compare the numbers of domestic sport volunteers and sport volunteer tourists at the Summer and Winter Olympic Games.
5. Provide suggestions for future research on volunteerism at the Olympics.

## Literature Review

### *Sport Volunteerism*

Volunteering has been a characteristic of human behavior since the earliest records of human communities (Mirsafian & Mohamadinejad 2012). The act of willingly giving up one's free time, resources, and effort through various endeavors has been observed over multiple decades of human history (Gaston & Alexander 2001). Mihajovic et al. (2010) describes volunteering as a means of fostering trust within communities, thereby strengthening the communities over time. This trust is essential for building strong, resilient communities capable of facing challenges.

Surujlal and Dhurp (2008) outline the three primary beneficiaries of volunteering: the volunteers themselves, the organizations they assist, and the communities in which the organizations are located. Volunteers gain personal satisfaction, new skills, and a sense of purpose, while organizations benefit from additional assistance and fresh perspectives. Communities, in turn, are enriched through enhanced services and strengthened social bonds. Moreover, Mirsafian and Mohamadinejad (2012) highlight three essential features of volunteering. These features are that volunteering must be: (1) voluntary, (2) performed without payment, and (3) mutually beneficial for both the individual volunteering and the organization for which they are volunteering. These characteristics ensure that the essence of volunteering remains rooted in altruism and communal benefit, fostering a cycle of giving and receiving that enriches all parties involved.

Sport volunteerism is a distinct subsection of volunteering, involving support for organizations connected to sports. From international mega-sporting events to local activities, volunteers are crucial to their success (Mirsafian & Mohamadinejad 2012). Cuskley (1998) and Green and Chalip (1998) describe sport volunteers as integral and indispensable to the sport industry, providing essential support in event management, logistics, and participant services. Volunteers help sporting events worldwide by reducing expenses and contributing fresh ideas (Shin & Kleiner 2003). This cost-saving aspect is vital for non-profit and smaller-scale events with limited budgets. Additionally, sport volunteerism enhances community spirit, offering volunteers valuable experiences and skills while promoting inclusivity and engagement. By involving diverse groups, sport organizations create more inclusive and representative events that resonate with a wide range of participants and audiences.

The pivotal role that volunteers play in the world of sports can be easily discerned from a statistical perspective as well. In Canada, over one million individuals are considered sport volunteers (Cuskelly at al. 2006). This trend is mirrored in Australia, where the proportion of sport volunteers remains substantial. Meanwhile, in England, the figure is even more striking, with the number of sport volunteers reaching 4.5 million (Cuskelly et al. 2006). The prominence of sport volunteers as a proportion of total volunteers within these countries further emphasizes their impact: 18% of Canadian volunteers, 26% of Australian volunteers, and 26.5% of English volunteers are involved in sports (Cuskelly et al. 2006). These figures demonstrate the heavy reliance of the sports industry on volunteer support, showcasing the vital importance of sport volunteerism to the broader volunteer sector. As Doherty (2009) suggests, such data underlines the integral contribution of volunteers in sustaining the sports industry and the broader implications this has for volunteerism.

### *Sport Volunteer Tourism*

In the context of sport volunteerism, there are further distinctions within this sub-section of volunteering. Researchers have described volunteer tourism as one of the fastest-growing alternative travel experiences (Pompurová et al. 2018). The key difference between volunteer tourists and other volunteers is that volunteer tourists work outside of their place of residence (Pompurová et al. 2018). Traditional volunteer tourism or voluntourism projects are organized by NGOs, local groups, associations, or local authorities (Pompurová et al. 2018). Voluntourism can occur under various circumstances: long-term, short-term, episodic, or occasionally (Pompurová et al 2018). Often, volunteer tourists, like domestic volunteers, contribute to the successful execution of a variety of events (Pompurová et al. 2018). Additionally, volunteer tourists may enhance the tourism potential of the locations where they volunteer (Pompurová et al. 2018).

Sport volunteer tourism primarily involves individuals traveling to volunteer for sporting events. Currently, there is limited research on examining the impact of sport volunteer tourists on the management of sporting events. Most research in this field focuses on understanding the motivational factors that drive people to participate in this form of volunteering (Jarvis & Blank 2011, Smith et al. 2016).

Perhaps one of the reasons why limited research exists on sport volunteer tourism is that the concept of "sport volunteer tourism" has been only scantly operationalized in literature. In 2006, Karlis delivered a Keynote address assessing the needs of "sport volunteer tourists" at the Olympic Games bringing focus on the newly conceptualized term of sport volunteer tourists. This Keynote address which was delivered at the 14th European of Sport Management Congress in Nicosia Cyprus brought to the forefront the importance of defining and examining sport volunteer tourism as a unique sub-group of sport volunteerism. The focus of Karlis' (2006) research centered around the fact that not all sport volunteers are tourists, as some are domestic residents who dwell in the city hosting the sport event. Thus, the call was put forth by Karlis in 2006 for researchers to further work on conceptualizing this notion while also enhancing research on sport volunteer tourism.

In subsequent research conducted on sport volunteer tourism, Karlis et al (2020) provide a historical overview of the conceptualization of sport volunteer tourism in research, while setting a direction for future research. Commencing with a historical overview of conceptual research on sport volunteer tourism, Karlis et al (2020) present how sport volunteer tourism has now started to be recognized as a unique part of the sport tourism experience. Karlis at al., (2020) in calling for more research on sport volunteer tourism conclude by stating the following directions for future research: (1) identify the attributes of conceptualizing sport volunteer tourism, (2) discern the attributes of sport volunteer tourists, (3) recognize the distinct types of sport volunteer tourism, (4) distinguish the distinct types of sport volunteer tourists, and (5) distinguish the concepts "sport volunteer tourism" from the concepts of "sport tourism" and "volunteer tourism."

In sum, it should be noted that the sport volunteer experience consists of two distinct and unique type of sport volunteers: (1) sport volunteers who are domestic, that is, reside in the host city in which the sport event is held, and (2) sport volunteer tourists who come from national or international places outside of the host city. Indeed, sport volunteer tourists, whether they are local residents or not, are a unique group, possessing an attribute to serve at a selected sport event, even if it costs them, as in the case of non-local residents, a large amount of money for travel and accommodation. Without a doubt, the need to serve and be a part of a specific mega sport event is what drives sport volunteer tourists to devote time, energy, money, and often their vacation to engage in this type of volunteer work (Karlis 2006).

*Volunteering and the Olympic Games*

The origin of contemporary volunteer movement of the Olympic Games dates to 1980 (Karlis 2008, Moreno 1999), when the organizing committee of the Lake Placid Winter Games pioneered a volunteer program to recruit and train around 6000 volunteers (Moreno, 1999). Since then, subsequent organizing committees have consistently utilized similar volunteer programs. Furthermore, the management of Olympic volunteers has progressed, adapting specific models to meet the diverse requirements of host cities over the years, including the recruitment of volunteers.

The most common model of recruiting volunteers for most mega-events is "program management" (Holmes et al. 2018). Organizing committees who used this model, such as during the London 2012 Games, focused on recruiting volunteers and placing them in respected volunteer positions, rather than focusing on the individual needs of each volunteer (Mejis & Hoogstad 2001, Mejis & Karr 2004). To enhance the volunteer experience and address hosting needs, numerous OCOG's have adjusted their volunteer program models over the years. For instance, the Sydney Summer Games in 2000 employed a pyramid approach, where organizers initially assigned specific volunteer roles before opening recruitment to the general population. This method ensured that critical positions were filled by individuals with the necessary skills and experience before expanding the search to include a broader pool of applicants (Holmes et al. 2018). In contrast, the 2008 Summer Games in Beijing adopted a targeted recruitment strategy, focusing on identifying the ideal volunteers for their program, with a particular emphasis on recruiting students. This approach aimed to leverage the enthusiasm and availability of younger volunteers (Zhuang & Girginov 2012). While there is no one-size-fits-all approach for recruiting volunteers for mega-events such as the Olympic Games, the necessity of these volunteers is vital to the successful running of sporting mega-events like the Olympics.

Those who volunteer at the Olympic Games commit their time not only during the Games but also in some cases before and after the Olympic Games take place. This commitment often includes participating in interviews, undergoing training sessions, and preparing for various roles that support the Games' operations. Leading up to the 2004 Summer Games in Athens, prospective volunteers were required to participate in a personal interview and comprehensive training sessions before the Games commenced (Karlis 2006). These sessions ensured that volunteers were well-prepared and understood their roles, contributing to a smoother execution of the event. While each National Olympic Committee operates uniquely, volunteer training typically includes sessions on Olympic history, hosting and customer service techniques, cultural awareness and sensitivity, and international relations (Karlis 2006). These training programs are designed to equip volunteers with the knowledge and skills needed to effectively interact with athletes, officials, and spectators from around the world. As an incentive for their dedication, volunteers often receive various benefits, including free uniforms, meals, refreshments, tickets to events during the Games, and ground transportation to the Olympic venues (Karlis 2006). These incentives help to recognize the volunteers' contributions and enhance their overall experience, making their time and effort feel valued and appreciated.

Existing research on volunteerism at the Olympic Games focuses on two broad categories: (1) the socio-psychological dimension of the volunteers, and (2) the management of volunteers. Research on the socio-psychological dimension of the volunteers focuses largely on motivations to volunteer, volunteer sustainability, satisfaction, and the impact of the volunteer experience (Kim et al. 2019, Teixera et al. 2023, Chaplin and Harris 2014)). Whereas research that exists on the management of Olympic volunteers primarily looks at recruitment and management techniques employed, legacies, and challenges in management (Holmes et al. 2024, Wicker 2017). This paper aims to contribute to the development of a third broad category of research on volunteerism at the Olympic Games – a research category that focuses on examining the state of condition of Olympic volunteerism. That is, an examination of trends and directions of volunteerism at the Olympic Games as well as the demographic composition of Olympic Games volunteers with an emphasis on domestic sport volunteers and sport volunteer tourists.

## Methods

This study employed a descriptive review approach to understand what has already occurred. Data came from existing papers and reports on Olympic volunteerism gathered through an extensive literature review, including information from the hosting OCOG's, to analyze trends and directions of Olympic volunteerism from 1980 to the present as well as available demographic information of Olympic volunteers on age, gender, and sport volunteerism. Data such as nationality and regional origin of volunteers was not presented as it was not available in a substantial amount to compose a meaningful descriptive review. The data used in this review has been summarized to provide a visualization of what has taken place using averages, percentages, and frequencies. The averages, percentages, and frequencies of the tables presented below help to identify trends, patterns, and relationships in a collective examination for all past Olympic Games since the commencement of the Olympic Games volunteer movement of Lake Placid 1980.

## Results

The results below present descriptive findings on Olympic Games volunteers from 1980 to 2024, beginning with frequency counts of volunteers of each of the Summer and Winter Olympic Games, as well as averages to summarize trends, patterns, and relationships. Basic demographics that were found for gender, age, and sport volunteerism are also presented. Data on domestic sport volunteers versus sport volunteer tourists in the form of frequencies and percentages are presented to better understand these two distinct groups of sport volunteers and their involvement in the Summer and Winter Olympic Games. It should be noted that every effort has been made to ensure the accuracy of the numbers presented below, yet no standardized instrumentation has been used collectively by all past OCOG's to present Olympic volunteerism thus posing accuracy limitations. The numbers that appear in the results below come from an attempt to put together in comparative format existing information made available by the respective OCOG's. Numbers, in some cases, have been rounded to present whole numbers for statistical, analytical and presentation purposes.

*Number of Volunteers at the Summer and Winter Olympic Games from 1980 to 2024*

In Table 1, the total number of volunteers at the Summer and Winter Olympic Games since Lake Placid 1980 is depicted. Both the Summer and Winter Olympic Games indicate a significant growth in the number of volunteers since the inauguration years of the Olympic volunteer movement, that is Lake Placid 1980 and Los Angeles 1984. Indeed, as Lake Placid 1980 utilized the least number of volunteers at 6,703, Nagano 1998 employed the highest number of Winter Olympic Games volunteers at 32,000. Since Nagano 1998, the range of Winter Olympic volunteers extends from the lowest recorded amount of 14,000 volunteers at Pyeongchang in 2018 to 25,000 volunteers relied on at both the Turin 2006 and Sochi 2014 Games.

For the Summer Olympic Games, the highest number of volunteers was recorded by Tokyo 2020 in which 70,900 volunteered their services. Indeed, since Atlanta 1996, the number of volunteers employed at the Summer Games has not dropped below 45,000. With the exception of Paris 2024, Athens, 2004, and Sydney 2000, the number of Summer Olympic Games volunteers has not dropped below 50,000, while Tokyo 2020, London 2010, and Beijing 2008 indicated 70,000 or more volunteers employed.

**Table 1.** *Total Number of Volunteers at the Summer and Winter Olympic Games from 1980-2024*

| Summer | Number of Volunteers | Winter | Number of Volunteers |
|---|---|---|---|
| Los Angeles 1984 | 28,742 | Lake Placid 1980 | 6,703 |
| Seoul 1988 | 27,221 | Sarajevo 1984 | 10,450 |
| Barcelona 1992 | 34,548 | Calgary 1988 | 9,498 |
| Atlanta 1996 | 60,422 | Albertville 1992 | 8,647 |
| Sydney 2000 | 47,000 | Lillehammer 1994 | 9,054 |
| Athens 2004 | 45,000 | Nagano 1998 | 32,000 |
| Beijing 2008 | 70,000 | Salt Lake City 2002 | 22,000 |
| London 2012 | 70,000 | Turin 2006 | 25,000 |
| Rio 2016 | 50,000 | Vancouver 2010 | 18,500 |
| Tokyo 2020 | 70,970 | Sochi 2014 | 25,000 |
| Paris 2024 | 45,000 | Pyeongchang 2018 | 14,000 |
| | | Beijing 2022 | 19,000 |

- Numbers indicated for Summer and Olympic Games from 2000 onwards are approximations.

To help visualize the patterns of volunteer involvement in the Winter and Summer Olympic Games from 1984 to 2024, Figures 1 and 2 have been created. Figures 1 and 2 illustrate that although the Summer and Winter Olympic Games continue to rely on a high number of volunteers the peak number reached in the past did not become the standard norm for Summer and Winter Olympic Games that followed. That is, subsequent Olympic Games after Tokyo 2020 and Nagano 1998 have not exceeded or matched the record setting numbers of volunteers employed at Tokyo 2020 and Nagano 1998.

**Figure 1.** *Number of Volunteers During Summer Olympic Games (1984-2024)*

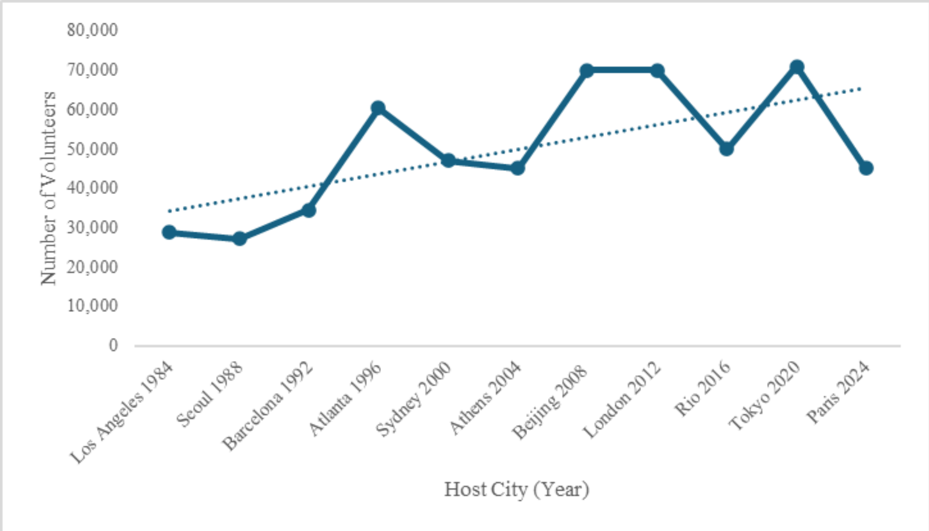
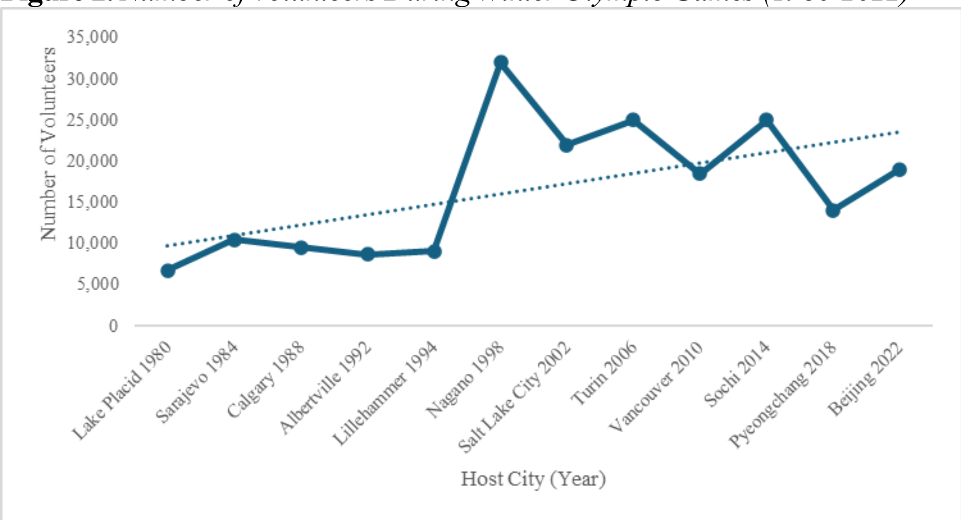



**Figure 2.** *Number of Volunteers During Winter Olympic Games (1980-2022)*




*Trends in Volunteering at the Summer and Winter Olympic Games*

The increase in the number of volunteers relied on for the delivery of services at both the Winter and Summer Games is identified in Table 2. For the six Winter Olympic Games that took place from 1980 to 1998, an average of 12,725 volunteers were called on to provide their services. From the first Games of the new millennium hosted by Salt Lake City in 2002 up until the recent Games of Beijing 2022, an average of 20, 583 volunteers were employed. Yet, since the start of the volunteer movement in Lake placid in 1980, an average number of 16,654 volunteers have been called on to provide services at the Winter Games.

By contrast, the average numbers of volunteers employed at the Summer Olympic Games (51,809) are larger than the Winter Olympic Games (16,654). Similarly to the Winter Olympic Games, the average number of volunteers employed at the Summer Olympic Games has increased post millennium. Indeed, the average number of volunteers (56,852) of the last seven Olympic Games since Sydney 2000 greatly surpasses the average number of volunteers of the previous four Olympic Games (37,733) from Atlanta 1996 and prior.

**Table 2.** *Average Number of Volunteers at Summer and Winter Olympic Games during Specific Time Periods*

| **Time Period** | **Average Number of Volunteers** |
|---|---|
| Summer Olympic Games (1984-2024) | 51,809 |
| Summer Olympic Games (1984-1996) | 37,733 |
| Summer Olympic Games (2000-2024) | 56,852 |
| Winter Olympic Games (1980-2022) | 16,654 |
| Winter Olympic Games (1980-1998) | 12,725 |
| Winter Olympic Games (2002-2022) | 20,583 |

## Demographics of Volunteers at the Summer and Winter Olympic Games

Very little secondary research is available that presents the demographic composition of volunteers at the Olympic Games. From the little content that is available on volunteering at the Olympic Games, demographic information has been found for Olympic Games held post 2000 that present figures for gender, age, as well as place of permanent residence of volunteers, that is, domestic sport volunteers and sport volunteer tourists.

Gender

Table 3 shows that, on average, the number of women surpasses men when it comes to volunteering at the Summer Olympic Games. Since the Games of Athens of 2004, more women have volunteered at all the Summer Games than men, with the two exceptions being the Athens 2004 Games that featured more men volunteers than women, and the Paris 2024 Games which had an even split in the number of men and women volunteers. In fact, at the London 2012 Games and at Tokyo 2020, for every 10 volunteers, approximately 6 were women and 4 were men.

**Table 3.** *Gender of Summer Olympic Games Volunteers from 2004-2020*

| Host city (year) | Men | Women |
|---|---|---|
| Athens (2004) | 53.5% | 46.5% |
| Beijing (2008) | N/A | N/A |
| London (2012) | 41% | 59% |
| Rio (2016) | 46% | 54% |
| Tokyo (2020)<br>Paris (2024) | 40.5%<br>50.0% | 59.5%<br>50.0% |
| Average (All Games) | 46.% | 54% |

Unlike the Summer Olympic Games, the Winter Olympic Games in Table 4 indicates slightly higher levels of average volunteer involvement by men (51%) in comparison to women (49%). Yet it should be noted that in two of the three Winter Olympic Games reported in the findings of Table 4, the number of women volunteers surpassed the number of men volunteers by over 8%. Indeed, the percentage of women volunteer involvement was found to be consistent at Vancouver 2010 (54.5%) and Pyeongchang 2018 (54%).

**Table 4.** *Gender of Winter Olympic Games Volunteers from 2006-2022*

| Host city (year) | Men | Women |
|---|---|---|
| Turin (2006) | 61% | 39% |
| Vancouver (2010) | 45.5% | 54.5% |
| Sochi (2014) | N/A | N/A |
| Pyeongchang (2018) | 46% | 54% |
| Beijing (2022) | N/A | N/A |
| Average (All Games) | 51% | 49% |

Age

Table 5 indicates that in Athens 2004 and Rio 2016 less than 10% of the volunteers were aged 55 and older. Conversely, in London 28% and in Tokyo 36% of the volunteers were 55 years of age and older. Most Summer Olympic Games volunteers tend to be between the ages of 16 – 35 (47%). The high number of volunteers in the younger age cohort was also substantiated in the most recent Games of Paris 2024. Although statistics available for the Paris Games do not use the same age range categories as the other Summer Olympic Games that appear in Table 5, 83% of the Paris 2024 volunteers were between the ages of 15 – 44 years of age, with only 17% of volunteers aged 45 and older. Please note that Paris 2024 is not included in Table 5 as the age range categories were not consistent with those of the previous Summer Olympic Games.

**Table 5.** *Age of Summer Olympic Game Volunteers from 2004-2020*

| Host city (year) | Aged 16-35 | Aged 36-55 | Aged 56+ |
|---|---|---|---|
| Athens (2004) | 63% | 30% | 7 % |
| Beijing (2008) | N/A | N/A | N/A |
| London (2012) | 35% | 37% | 28% |
| Rio (2016) | 63% | 29% | 8% |
| Tokyo (2020) | 27% | 37% | 36% |
| Average (All Games) | 47% | 33% | 20% |

Similarly, to the Summer Olympic Games, most volunteers at the Winter Olympic Games are 55 years of age and under, with 46% between the ages of 16-35 years of age and 29% between the ages of 36-55 (see Table 6). From available statistics on the number of volunteers aged 55 and older, it was found that at the Winter Olympic Games the number of volunteers surpassed the number of volunteers at the Summer Olympic Games by 5%. It should be noted that although Beijing 2022 reported that 93% of its volunteers were between the ages of 16-35, these numbers were not factored in Table 6 as statistics on the number of volunteers in the other two age categories were not found. Nonetheless, just like Turin 2006 and Pyeongchang 2018, Beijing 2022 identifies the age group of 16-35 to consist of the greatest number of volunteers at the Winter Olympic Games.

**Table 6.** *Age of Winter Olympic Game Volunteers from 2006-2022*

| Host city (year) | Aged 16-35 | Aged 36-55 | Aged 56+ |
|---|---|---|---|
| Turin (2006) | 47% | 20% | 33% |
| Vancouver (2010) | 30% | 37% | 33% |
| Sochi (2014) | N/A | N/A | N/A |
| Pyeongchang (2018) | 62% | 31% | 7% |
| Average (All Games) | 46% | 29% | 25% |

*Domestic Sport Volunteers and Sport Volunteer Tourists*

Although very little information is available on place of permanent residence of Olympic volunteers, information that is available shows that the bulk of volunteers at the Summer Olympic Games are domestic residents, that is domestic sport volunteers (see Table 7). International residents, that is, sport volunteer tourists, accounted for less than 10% of the total number of volunteers at London 2012 and Rio 2016. However, at the most recent Summer Olympic Games held in Paris 2024, a significant increase took place, with 20% of volunteers recognized as sport volunteer tourists

**Table 7.** *Domestic Sport Volunteers and Sport Volunteer Tourism at the Summer Olympic Games Volunteers from 2004-2020*

| Host city (year) | Domestic Sport Volunteers | Sport Volunteer Tourists |
|---|---|---|
| Athens (2004) | N/A | N/A |
| Beijing (2008) | N/A | N/A |
| London (2012) | 97% | 3% |
| Rio (2016) | 90% | 10% |
| Tokyo (2020)<br>Paris (2024) | N/A<br>80% | N/A<br>20% |
| Average (All Games) | 89% | 11% |

Statistics presented in Table 8 for the Winter Olympic Games are approximate numbers made available by the respected OCOG's. Yet, from these estimated numbers, comparisons can be made with the figures presented for the Summer Olympic Games. Specifically, the Summer Olympic Games indicate in Table 7 a less reliance on domestic sport volunteers than the Winter Olympic Games. Whereas, the number of sport volunteer tourists, are reported to be greater on average in the Summer Olympic Games (11%) than in the Winter Olympic Games (6%).

**Table 8.** *Domestic and International Winter Olympic Games Volunteers from 2006-2022*

| Host city (year) | Domestic Sport Volunteers | Sport Volunteer Tourists |
|---|---|---|
| Turin (2006) | N/A | N/A |
| Vancouver (2010) | 95% | 5% |
| Sochi (2014) | 92% | 8% |
| Pyeongchang (2018) | 95% | 5% |
| Beijing (2022) | N/A | N/A |
| Average (All Games) | 94% | 6% |

## Discussion

To fulfill the objectives of this paper, existing data on Olympic volunteerism was gathered through an extensive literature review as well as from information of host OCOG's to derive an analysis of trends and directions of Olympic volunteerism from 1980 to the present. The data gathered was summarized by averages, percentages, and frequencies and several key findings were identified that could lead to stimulate further research.

### *Number of Volunteers*

Mega sport events rely on sport volunteers to assist in implementing day-to-day functions and operations of the Games. The Summer and Winter Olympic Games are no exception. Indeed, the rich history of the Olympic Games has made this mega sport event perhaps the highest profiled mega sport event globally. Research indicates that attracting and recruiting volunteers for the Summer and Winter Olympic Games has not been difficult, as many apply to volunteer, yet only not all are chosen for limited volunteer positions (Noordegraaf/Celibi 2015).

As the number of volunteer positions available depend on the OCAG's, it needs to be pointed out that the increasing number of volunteers at the Summer and Winter Olympic Games is probably a reflection of: (1) a greater reliance on volunteers to provide services, (2) the growth and expansion of the Olympic Games, and (3) the need to provide a growing number of services to spectators (Karlis, 2006). It appears that with each passing Olympic Games, the volunteer movement becomes stronger with many lasting benefits.

The smallest number of volunteers at the Summer Olympic Games was in Los Angeles (28,742), whereas the largest number of volunteers at the Summer Olympic Games was Tokyo 2020 (70,970). Similarly, the smallest number of volunteers at the Winter Olympic Games was in Lake Placid 1980 (6,703), whereas the largest number of volunteers at the Winter Olympic Games was Nagano 1998 (32,000). Although the most recent Summer Olympic Games, Paris 2024, employed less volunteers 26,470 than Tokyo 2020, it is highly unlikely that less than 45,000 volunteers will be relied on for future Summer Olympic Games as all Summer Olympic Games since Atlanta 1996 have employed 45,000 or more volunteers. The same can be said for the number of volunteers for future Winter Olympic Games. The most recent Winter Olympic Games, Beijing 2022, relied on 13,000 less volunteers than Nagano 1998, but since Nagano 1998, except for Pyeongchang (14,000), all Winter Olympic Games have been assisted with the service of no less than 18,000 volunteers.

*Trends in Volunteering*

According to Essex and Chalkley (2007) the Summer Olympic Games are widely perceived as the more popular of the Winter Olympic Games because of a larger audience both in person and on television, as well as a greater number of nations participating in the events leading to more athlete involvement. Not only do the number of volunteers historically reflect the popularity of the Summer Olympic Games, the trend indicating a greater growth in volunteer participation at the Summer Olympic Games in comparison to the Winter Olympic Games also ascertains this higher popularity of the Summer Olympic Games.

The findings of this paper revealed that from 1980-2024, the average number of volunteers for the Summer Olympic Games (51,809) greatly surpasses the average number of volunteers for the Winter Olympic Games (16,654). For the Summer Olympic Games, the average number of volunteers for 1984-1996 was 37,733 whereas for the Summer Olympic Games held from 2000-2024 the average number of volunteers increased significantly to 56,852. This was an increase of almost 20,000 volunteers. For the Winter Olympic Games on the other hand, the average number of volunteers for 1980-1998 was 12,725 whereas from 2002-2022 the average number of volunteers increased significantly to 20,583, yet the increase of approximately 8,000 volunteers is much less than the increase of almost 20,000 volunteers experienced by the Summer Olympic Games.

A growing trend to increasing volunteer use is evident for both the Summer and the Winter Olympic Games. This trend should come as no surprise as the staging of the Summer and Winter Olympic Games has become bigger, and the interest to serve as a sport volunteer has become more popular in recent years (Karlis, 2006). The fact that the Summer and Winter Olympic Games offer an elite level of competition also helps in stimulating a greater interest for people to serve as sport volunteers at these mega sport events.

This growing trend to increasing volunteer reliance for both the Summer and Winter Olympic Games has significant practical implications for future OCOGs. The consistent reliance on volunteers in high numbers exceeding 45,000 for Summer Olympic Games and 18,000 for Winter Olympic Games means that organizing committees must continue to place a high importance on volunteers and the services they provide. Practically, this requires host cities to dedicate substantial resources and years of advance planning to recruitment, training, scheduling, and logistics—such as transport, uniforms, etc. —to support these high numbers of volunteers. As the Olympic Games continue to grow, the capacity of an OCOG to effectively manage this high number of volunteers will be a critical factor in the overall operational success of future Olympic Games.

*Demographics*

Gender

The results of this paper found that on average, more women (57%) volunteer at the Summer Olympic Games than men (46%). Yet, at the most recent Summer Olympic Games, 50% of the volunteers were women and 50% were men. Although slightly more men (51% than women (49%) participate on average at the Winter Olympic Games, in two of the most recent Winter Olympic Games it was found that women had a much greater volunteer involvement than men, at Vancouver 2010 (54.5%) and Pyeongchang 2018 (54%).

The gender difference in volunteering at the Summer and Winter Olympic Games may reflect potential gender differences in the motivations for volunteering (Alexander et al 2015, Hallman et al 2020, Khoo et al 2011). Downward and Ralston (2005) for example identify significant differences in men and women volunteers with personal interest and skill acquisition. Further research by Skirstad and Hanstad (2013) mentioned different motivating factors for men and women in volunteering at mega sport events, with women more than men using the mega sport event to raise their personal and social capital. Whereas Dorsch et al., (2002) identify a sense of obligation as being a key factor that drives men to volunteer whereas social interaction and helping others were attributes motivating women to volunteer.

Age

The findings of this study revealed that adults over 55 years of age volunteer less, on average, at the Summer and Winter Olympic Games than the other age cohorts. Turin 2006 however, was the only Olympic Games to have reported a higher number of senior adult volunteers over 55 years of age as compared to adult volunteers aged 36-55. The highest number of volunteers however is identified in the 16-35 age cohorts for both the Summer Olympic Games (47%) and the Winter Olympic Games (46%). Perhaps this is reflection of a greater interest in sport by the younger adults as compared to older adults.

The findings of this study also revealed that Tokyo 2020 (36%) reported the highest number of volunteers over 55 years of age of all Summer Olympic Games, whereas Vancouver 2010 (33%) and Turin (33%) indicated the greatest volunteer involvement of the Winter Olympic Games for the same age cohort. That is, at least for these three Olympic Games, older adult volunteer participation was at a high level. This high level could reflect a senior volunteer ethic of the people of Japan, Canada, and Italy.

Research identified several different factors related to age difference and volunteering at the Olympics. Fyffe and Wister (2014) found in a study of volunteers following the Vancouver 2010 Games, that for middle aged adults, self-esteem and meaning of life were outcomes of the volunteer experience whereas for older adults the outcomes were sense of belonging and meaning in life. Further research by Dorsch et al (2002) revealed social interaction, recognition, and career advancement as influencing factors to motivate younger adults to volunteer at mega sport events, whereas for older adults a motivating factor to volunteer was helping the community.

The consistent dominance of the 16–35 age cohort suggests that this group of volunteers will bring assets unique to this age cohort such as advanced technological skills to the volunteer experience. Conversely, the high participation of older adults in past Olympic Games like Tokyo 2020 and Vancouver 2010 highlights a senior volunteer ethic that OCOGs can tap into for roles requiring mentorship, local historical knowledge, and long-term community stability. The practical takeaway for administrators is the need for intergenerational volunteer management strategies that pair the cohort specific assets of younger volunteers with the cohort specific assets of older participants.

*Domestic Sport Tourists and Sport Volunteer Tourists*

This research study found that most volunteers at the Summer and Winter Olympic Games are domestic sport volunteers. This is not surprising as countries receive hosting the Summer and Winter Olympic Games with excitement and enthusiasm and attempt to pass this enthusiasm and excitement on to the citizens of their countries.

The results of this study found that sport volunteer tourists offer their services more at the Summer Olympic Games (11%) as compared to the Winter Olympic Games (6%). On the other hand, the Winter Olympic Games tend to rely more on domestic sport volunteer than the Summer Olympic Games. This may be a result of seasonality as the summer months tend to be more popular for travelling and vacationing for those seeking the sport volunteer experience.

As sport volunteer tourism continues to increase in popularity, (Pompurová et al. 2018), it is beneficial for researchers and administrators to recognize that sport volunteers consist of two groups – sport volunteers that are domestic and sport volunteer tourists that are international. Although the outcome of the volunteer experience of enrichment, community contribution, and positive life experience may be the same for domestic sport volunteers and sport volunteer tourists (Doherty 2009), these are two distinct groups of sport volunteers who are likely to have distinct needs and unique interests as well.

The growing presence of sport volunteer tourists, particularly in the Summer Olympic Games, signals the emergence of a highly mobile group of individuals who travel internationally to provide sport volunteer tourism services. While host cities benefit from this specialized experience and the associated tourism spending, the high reliance on domestic sport tourists in Winter Olympic Games suggests a more localized cultural need for volunteers. For future host committees, the challenge lies in leveraging the expertise of sport volunteer tourists without overlooking to recruit domestic sport tourists. Managing these two distinct groups requires tailored logistics, as sport volunteer tourists may require more intensive support regarding housing and accreditation, whereas domestic sport tourists offer a ethno-cultural attachment of sport engagement within their host nation.

*Recommendations for Future Research on Volunteerism at the Olympics Games*

Research on volunteerism at the Olympics not only helps enhance the body of knowledge on sport volunteerism and the state of condition of Olympic volunteerism, it also may be of assistance to administrators of the Olympic Games, such as OCOG's or IOC administrators. Through enhanced research, administrators of the Olympic Games and others interested in the volunteer movement at the Olympic Games would be in a better position to overview and articulate past trends and directions of Olympic Games volunteerism. More research may also contribute to an enhanced knowledge base on the make-up and composition of Olympic Games volunteers. In addition, expanded research may also assist to better understand volunteerism at the Olympic Games in comparisons to other mega sport events. Below are suggestions for what type of research needs to be conducted to contribute to existing research on volunteering at the Olympic Games.

Recommendation 1: Conduct regular studies on the trend and direction of volunteerism at the Summer and Winter Olympic Games. Since the volunteer movement started in Lake Placid in 1980, little research has been done to identity and compare the number of volunteers of all Summer and Winter Olympic Games. Numbers say a lot. Numbers identify trends and directions. Numbers also identity growth and decline. By doing a regular overview of the changing number of volunteers at the Summer and Winter Olympic Games researchers will be able to recognize not only trends and directions during specific time periods, but also the value placed on volunteerism at the Olympics.

Recommendation 2: Enhance understanding of demographic composition of volunteers of past Olympic Games.

Demographics describe the big picture by providing statistical information on characteristics such as gender, age, income, and education. Currently, there is a lack of data on the demographic composition of volunteers at past Summer and Winter Games. Indeed, prior to 2000, it is difficult to find demographic information on volunteers. Little demographic information is available post 2000 that focuses on gender and age. Further, demographic information on education and income of volunteers would also be helpful in giving Olympic administrators a good overall picture as to who the volunteers are. To better understand trends in volunteering at the Olympics as well as identity patterns of volunteers, more demographics research is needed.

Recommendation 3: Enhance research on sport volunteerism and its relevance to the Olympic Games.

Research on sport volunteerism is still quite young. It was in the late 1990s that sport volunteer research started to emerge with the works of Auld (1997) and Cuskelly et al. (1998). Very little has been researched on sport volunteerism at the Olympics, as well as the impact the sport volunteer has on the Olympics and following the completion of the Olympic Games (Wang et al. 2019). More research is needed to better understand the significance and impact of the sport volunteer at the Summer and Winter Olympic Games.

Recommendation 4: Examine sport volunteer tourism and its impact on the Olympic Games.

Both the Summer and Winter Olympic Games are popular with a unique group of sport volunteers that come from international countries, these are sport volunteer tourists. Just like the concept of sport volunteerism, the concept of sport volunteer tourism is relatively new in research, having come to the forefront in research in the early 2000s (Karlis et al. 2020). Little research has been conducted on understanding sport volunteer tourism, with even less research placed on recognizing who the sport volunteer tourists are at the Olympic Games. As the number of sport volunteer tourists continue to increase at the Olympic Games, more research is needed that focuses on enhancing knowledge as to who these individuals are and what motivates them to become sport volunteer tourists at the Olympic Games.

Recommendation 5: Explore the uniqueness and significance of volunteering at the Olympics.

Volunteering at the Olympics is unique due to its global scale, prestigious nature, and the diverse roles available. Volunteers gain invaluable experiences and contribute significantly to the Olympic Games success and legacy. As the Olympic Games continue to evolve and change, so do people. By conducting more research on getting to know the "experience" and "outcomes" of volunteering at the Olympic Games, administrators of the Olympic Games would be in a better position to understand who today's sport volunteers are and what expectations sport volunteers have from the volunteer experience offered by the Olympic Games.

## Conclusion

This paper used a descriptive review to provide a comparative overview of volunteering at the Olympic Games from 1980 to 2024. Using secondary data, this paper: (1) compared the number of volunteers from 1980 to 2024, and (2) presented existing data on demographics of volunteers. The results identified: (1) a significant growth in the number of Summer and Winter Olympic Games volunteers since 1980, (2) a growing trend to increasing volunteer reliance for both the Summer and the Winter Olympic Games when comparing volunteer numbers pre and post 2000, (3) more women volunteer at the Summer Olympic Games and slightly more men volunteer at the Winter Olympic Games, (4) the highest number of Olympic Games volunteers come from the 16-35 age cohort, and, (5) both the Summer and Winter Olympic Games rely primarily on domestic sport volunteers while the Summer Olympic Games attracts more sport volunteer tourists than the Winter Olympic Games.

Every effort has been made to ensure the accuracy of the numbers presented in this paper, yet the lack of available information and the lack of consistency in the categorical breakdown of these numbers in existing documentation should be mentioned as it may reflect the accuracy in the numbers presented. Indeed, it would be helpful for comparative purposes that future OCOG's utilize a consistent and standardized process to measure the number of volunteers and demographics. Nonetheless, the limited numbers and information available on Olympic volunteerism have been put together in this paper to make a case of the importance of Olympic volunteerism and its trends and directions.

Olympic volunteerism is indeed essential to the organization and execution of the Olympic Games. Since the Lake Placid Games, the number of volunteers has consistently increased. The International Olympic Committee (IOC) has repeatedly emphasized volunteers' crucial role in the Games' success (IOC, n.d.). The findings of this study have been put together to contribute to a better understanding of trends and directions of volunteering at the Summer and Winter Olympic Games. The paper concluded with suggestions for future research that have also been put forth to help administrators of Olympic Games better understand and recognize not only trends and directions of volunteerism at the Olympic Games, but also the demographic composition of volunteers from the limited data available. The sport volunteer has also been distinguished from the sport volunteer tourist and emphasis has been placed on the need for more research to better understand Olympic Games volunteers. To enhance our understanding of Olympic volunteerism, future research should focus on identifying the various characteristics of Olympic volunteers, such as their demographics and trends as little research exists that does this.

## References


Alexander A, Kim SB, Kim DY (2015) Segmenting volunteers by motivation in the 2012 London Olympic Games. *Tourism management*, *47*, 1-10.https://doi.org/10.1016/j.tourman.2014.09.002

Auld CJ (1997) Professionalisation of Australian sport administration: The effects on organisational decision making. *European Journal for Sport Management*, *4*(2), 17-39. https://doi.org/10.1080/1029712X.1997.12426442

Chaplin D, Harris J (2014) *Pugilistic pastoring: Volunteering in amateur boxing as missionary work*. Chapter Nineteen in Fighting: Intellectualising combat sports Champaign, IL: Common Ground Publishing, Editor-in-Chief: Keith Gilbert, University of East London (U.K.). ISBN: 978161224315.

Cuskelly G, Hoye R, Auld C (2006) *Working with volunteers in sport: Theory and practice*. Routledge. https://doi.org/10.4324/9780203966822

Cuskelly G, McIntyre N, Boag A (1998) A longitudinal study of the development of organizational commitment amongst volunteer sport administrators. *Journal of Sport Management*, *12*(3), 181-202.DOI:10.1123/jsm.12.3.181

Cuskelly G (1998) Organisational commitment and committee turnover of volunteers in sport. *Australian Journal on Volunteering*, 3(2), 4-14.

Doherty A (2009) The volunteer legacy of a major sport event. *Journal of policy research in tourism, leisure and events*, *1*(3), 185-207. https://doi.org/10.1080/1940796090320 4356

Downward P, Lumsdon L, Ralston R (2005) Gender differences in sports event volunteering: Insights from Crew 2002 at the XVII Commonwealth Games. *Managing Leisure*, 10(4), 219-236.https://doi.org/10.1080/13606710500348086

Dorsch K, Reimer H, Sluth V, Paskevich D, Chelladurai P (2002) *Volunteer motivation: What drives sport volunteers?* International year of volunteers research program. Toronto: Canadian centre for philanthropy, Retrieved 05/01, 2012.

Essex S, Chalkley B (2019) Mega-sporting events in urban and regional policy: a history of the Winter Olympics. *Journal of Sports and Science*, *40*(2), 54-67.https://doi.org/10.1080/02665430420001924 75

Fyffe I, Wister AV (2016) Age differences in Olympic volunteering experiences: An examination of generativity and meaning in life. *Leisure Studies*, *35*(5), 638-651. DOI:10.1080/02614367.2014.994554

Gaston K, Alexander JA (2001) Effective organisation and management of public sector volunteer workers: police special constables. *International journal of public sector management*, *14*(1), 59-74. DOI:10.1108/09513550110387075

Green BC, Chalip L (1998) Sport volunteers: Research agenda and application. *Sport Marketing Quarterly*, *7*(2), 14-23. DOI:10.1177/106169349800700204

Hallmann K, Zehrer A, Fairley S, Rossi L (2020) Gender and volunteering at the Special Olympics: Interrelationships among motivations, commitment, and social capital. *Journal of Sport Management*, *34*(1), 77-90.https://doi.org/10.1123/jsm.2019-0034

Holmes K, Nichols G, Ralston R (2018) It's a once-in-a-lifetime experience and opportunity—Deal with it! Volunteer perceptions of the management of the volunteer experience at the London 2012 Olympic Games. *Event management*, 22(3), 389-403. DOI: 10.3727/152599518X15252895715050

Holme K, Smith KA, Lockstone-Binney L, Shipway R, Ong F (2024) Volunteering legacies from the Olympic Games: Missed opportunities. *VOLUNTAS: International Journal of Voluntary and Nonprofit Organizations*, 35(4), 768-779. DOI:10.1007/s11266-024-00643-w

International Olympic Committee [IOC] (n.d.) https://olympics.com/en/olympic-games

Jarvis N, Blank C (2011) The importance of tourism motivations among sport event volunteers at the 2007 World Artistic Gymnastics Championships, Stuttgart, Germany. *Journal of Sport & Tourism*, 16(2), 129-147. DOI:10.1080/14775085.2011.568089

Karlis G, Stratas A, Hamidi W, Kantartzi IM (2020) Conceptualizing sport volunteer tourism: Setting a direction for future research. *The Sport Journal*, *21*(6), 1-14. https://thesportjournal.org/article/conceptualizing-sport-volunteer-tourism-setting-a-direction-for-future-research/

Karlis G (2013) The Olympic Volunteer and Olympic Education: Suggestions for Administrators of Olympic Games. *Voluntaris*, *1*(2), 116-126.

Karlis G (2003) Volunteerism and multiculturalism: A linkage for future Olympics. *The Sport Journal*, 6(3), 1-16. https://thesportjournal.org/article/volunteerism-and-multiculturalism-a-linkage-for-future-olympics/

Karlis G (2006) *Assessing the needs of "sport volunteer tourists" at the Olympic Games: Implications for administrators of mega sport events.* In Keynote address presented at the 14th congress of the European Association for Sport Management, Nicosia, Cyprus.

Kim M, Kim SSK, Kim M, Zhang JJ (2019) Assessing volunteer satisfaction at the London Olympic Games and its impact on future volunteer behaviour. *Sport in Society*. https://doi.org/10.1080/17430437.2019.1616926

Khoo S, Engelhorn R (2011) Volunteer motivations at a national Special Olympics event. *Adapted physical activity quarterly*, 28(1), 27-39. DOI: 10.1123/apaq.28.1.27

Moreno AB, Moragas M, Paniagua R (1999) *The evolution of volunteers at the Olympic Games.* Proceedings of the Volunteers, Global Society and the Olympic Movement, Lausanne, Switzerland, 24-26.

Mihajlovic M, Komnenic N, Kastratovic E, Cilerdzic V (2010) Volunteers in sport organizations.

Meijs L, Hoogstad E (2001) New Ways of Managing Volunteers: Combining Membership Management and Programme Management. *Voluntary Action*, vol 3, no. 3, pp. 41–61.

Meijs LC, Karr LB (2004) *Managing Volunteers in Different Settings: Membership.* Volunteering as leisure/leisure as volunteering: An international assessment, 177.

Mirsafian H, Mohamadinejad A (2012) S*port volunteerism: a study on volunteering motivations in university students*. DOI:10.4100/jhse.2012.7.Proc1.09

Noordegraaf MA, Çelebi M (2015) The challenges of the volunteerism process during international sport organizations/events. *Journal of Human Sciences*, 12(1), 1263-1279. DOI:10.14687/ijhs.v12i1.3238

Pompurová K, Marčeková R, Šebová Ľ, Sokolová J, Žofaj M (2018) Volunteer tourism as a sustainable form of tourism—The case of organized events. *Sustainability*, *10*(5), 1468.https://doi.org/10.3390/su10051468

Skirstad B, Hanstad DV (2013) Gender matters in sport event volunteering. *Managing Leisure*, *18*(4), 316-330. DOI:10.1080/13606719.2013.809188

Smith NL, Cohen A, Pickett AC (2014) Exploring the motivations and outcomes of long-term international sport-for-development volunteering for American Millennials. *Journal of Sport & Tourism*, *19*(3-4), 299-316.DOI:10.1080/14775085.2016.1143865

Surujlal J, Dhurup M (2008) Volunteers\'perceptions of benefits derived from volunteering: an empirical study. *South African Journal for Research in Sport, Physical Education and Recreation*, *30*(1), 105-116. DOI:10.4314/sajrs.v30i1.25987

Teixeira MC, Banza T, Almeida N, Sesinando A (2023) Sport mega-events, volunteer motivation, and self-assessment: reasons and expectations for participating in the Rio 2016 Olympic Games. *Journal of Physical Education and Sport*, *23*(5), 1221-1236. DOI:10.7752/jpes.2023.05151

Wicker P (2017) Volunteerism and volunteer management in sport. *Sport management review*, *20*(4), 325-337. DOI:10.1016/j.smr.2017.01.001

Wang Y, Derom I, Theeboom M (2023) Volunteering at the Olympic and Youth Olympic Games: More Than a Distant Memory? *Journal of Global Sport Management*, *8*(1), 361-385.https://doi.org/10.1080/24704067.2021.1871857

Zhuang J, Girginov V (2012) Volunteer selection and social, human and political capital: a case study of the Beijing 2008 Olympic Games. *Managing Leisure*, *17*(2-3), 239-256. DOI:10.1080/13606719.2012.674397

*Athens Journal of Sports - Volume 13, Issue 2, June 2026 – Pages 139-152*

# Rethinking the Central Midfielder: Intelligence over Power in the Modern Football

*By Arman Sargsyan**

*In modern football, the central midfielder has evolved from a role defined by physicality and stamina into one of strategic intelligence, creativity, and mental agility. This paper questions this stereotype and instead posits that the essential qualities for a midfielder are more technical and cerebral in nature, contributing to their ability to control the tempo of the game, making fast and correct decisions under pressure.Utilizing game examples and analyses of top-tier players like Xavi Hernández, Andrés Iniesta, Luka Modrić, Andrea Pirlo, Sergio Busquets, Vitinha and Pedri the study highlights the importance of high-level decision-making, spatial understanding, and anticipation in the midfield role across different top teams. The study also examines the psychological aspects of midfielders, discussing the importance of concentration, composure under pressure and rapid decision-making, especially in high-intensity possession-based systems such as those used by Barcelona, PSG, and Manchester City. The paper further compares players who have little physical dominance but possess high levels of footballing intelligence. This aspect of the study aims to be more inclusive, prompting coaches and scouts to focus more on nurturing players who exhibit vision, creativity and mental agility, despite their potential lack of elite physical attributes. The study also offers a critique on current footballing trends and practices, particularly those that may inadvertently discourage or overlook technically skilled yet less physically imposing midfielders. Suggestions are made on how to incorporate cognitive training in player development and in youth academies, to encourage the retention of diverse midfielder profiles.*

**Keywords:** *Central Midfield Performance, Perceptual–Cognitive Expertise, Decision-Making Under Pressure, Talent Identification in Football, Youth Player Development*

## Literature Review

### *The Physical Emphasis in Modern Football & Talent Identification*

Football has incorporated sport science and performance analysis as key core in its approach to player development and recruitment over the last 20 years. GPS data, sprint speeds, high-intensity running volumes, duel success rates, and biometric analysis have become more common at all levels, in particular within youth academies, with analysis software systems now key parts of almost any player assessment. These tools have allowed for better conditioning standards and specific load management and can certainly help with identification of useful physical qualities in players. However, they have also, at times, led to a potentially unintended and flawed evaluative bias: that

*Independent Researcher, Soccer Coach, Youth Soccer Development, Scout and Author, PFSA Scouting Association, UK & US Soccer Federation, USA.

players who are more physically developed at a younger age are considered to be more "ready" or more "talented", even if the long-term performance profile of the position is in many ways more related to cognitive and technical characteristics. Central midfield is one of the positions on the pitch most affected by this trend. Functioning as the tactical engine of the team, a central midfielder is expected to receive the ball under pressure, link build-up with attack, control transition, and maintain positional balance. These playmaking functions require a wide range of often decisive actions and decisions: creating angles and space to receive, scanning for passing lanes and threats, manipulating available space with subtle movements, slowing or accelerating tempo with their choice of pass. However, in many youth environments, physical strength (speed, size, power, and general physicality) can create short-term impact in matches, and inflated levels of match activity can in turn affect talent identification processes or selection decisions. This means that technically inclined and cognitively strong players can be overlooked because they lack standout attributes or do not immediately excel in physically intense youth environments. A related structural factor that compounds this issue in many contexts is the "early-maturation advantage", which is commonly referenced in development literature as the Relative Age Effect, or more simply, being born earlier in the competitive year (or at a training facility) correlating with a higher likelihood of being selected and provided higher-quality coaching and competitive environments. This structural bias is widely documented in youth sport literature as the Relative Age Effect (Cobley et al. 2009, Helsen et al. 2005).

Players who mature earlier and physically are often stronger, faster, more powerful, and therefore stronger and more physically dominant than those who mature later physically. The latter players are in some contexts filtered out too early, despite likely possessing better football intelligence, superior technical qualities, and the positional understanding to maximize their skills. In central midfield, this is especially damaging because the position is often one that rewards the decision-making and the spatial control of the ball that are not always as visible at lower or earlier levels of the sport, but which are increasingly exposed at higher tactical levels as these players age. The main argument of this paper is therefore not that physical qualities do not matter in modern football – they do – but that physical dominance is often being prioritized as the main predictor of future central midfield quality and performance, when in fact the most consistent differentiator is cognitive efficiency coupled with high levels of technical execution (Vaeyens et al. 2008).

## Decision-Making under Pressure: Perception, Scanning, and Tempo Control

Central midfielders operate in the most information-dense zone of the pitch. In space between defensive and offensive structures, midfielders are surrounded by opponents, teammates, and constantly shifting passing lanes. These players also have less time to make decisions. For this reason, elite performance in the midfield is closely linked to a concept known as perception–action skill: the ability to read the environment (under pressure) and translate that information into effective actions in a limited time. At the tactical level, this concept encompasses all sorts of skill such as pre-orientation (checking shoulders before receiving), scanning frequency, pressing triggers, teammate movement patterns, and opponent anticipation. Scanning, in particular, is a critical cognitive component of this skillset. A central midfielder who scans frequently and consistently before receiving will cut decision time in half once in possession. This leads to faster circulation, cleaner execution, and less turnovers, particularly against teams that play with high pressure. Scanning is not simply "looking around" it is an intentional cognitive action that looks for pressure, maps teammates, and reads space. When done to a high level, scanning enables midfielders to play with less touches, which is often the difference between beating pressure or losing possession in the modern elite game. Tempo control is another fundamental cognitive component. Elite midfielders instinctively know when to "speed up the game" with vertical passes and progressive carries, and when to "slow down the game" with recycling passes that re-establish structure (Araújo et al. 2006, Mann et al. 2007).

The ability to control tempo is not a physical skill: it is a tactical and psychological skill that stems from understanding when and how to make these decisions. Under aggressive pressing structures, this composure is even more valuable. The midfielder who keeps his or her head under pressure can play the pass that breaks the press, while a more physically dominant, but cognitively rushed player will play the safe option over and over again (slow down attacking progress) or attempt a forced action at the wrong time (resulting in loss of possession). Cognitive quality also matters defensively. Intelligent midfielders often look "not fast," but they are on time because they "get there early." They cut passing lanes with their positioning rather than by running. They intercept because they read rather than react late. In this way, intelligence at the midfield level can obviate the need for constant physical emergency defending because smart midfielders can prevent danger before it happens (McGuckian et al. 2018, Aksum et al. 2021).

## The Elite Midfield Profile: Intelligence as a Competitive Advantage

Coaching analysis and tactical research converge on the archetype of the central midfielder as a mentally sharp and technically sound player. Teams that excel in possession-based play and orchestrate the rhythm of the match tend to coalesce around midfielders who provide consistent structure and correct decision-making. A retrospective on FC Barcelona's midfield, including the likes of Xavi Hernández, Andrés Iniesta, and Sergio Busquets, exemplifies a paradigm of cerebral dominance. Their collective dominance was anchored not in physicality but in positional acumen, swift decision-making in passing, and creating numerical advantages through intelligent movement and ball circulation. Andrea Pirlo's transformation into a deep-lying playmaker is another testament to how a player can orchestrate top-tier matches with vision and passing range, while forgoing speed or physical assertiveness. Luka Modrić's ability to thrive in elite midfield positions, even against younger and quicker players, provides a contemporary exemplar of world-class midfield intelligence operating at high tempo. These examples collectively underscore the notion that top central midfielders are not necessarily the ones who win physical duels but rather those who dominate temporally: creating it, stealing it, and exploiting it to steer the game. This literature review thus reinforces the paper's central thesis: central midfield excellence is a cognitive-technical phenomenon. Physical attributes still play a role in aspects like stamina and one-on-one situations, but intelligence becomes the critical differentiator at the elite level. It influences the frequency with which a midfielder is in the right place at the right time, the speed of selecting the right action, and the ability to effectively link different areas of the team. Accordingly, player development systems and talent identification methodologies should place greater emphasis on intelligence and technical prowess, rather than defaulting to physical attributes as the primary barometer for midfield potential (Mann et al. 2007, Araújo et al. 2006).

## Methodological Approach and Analytical Framework

This study employs an in-depth and qualitative approach, considering the multifaceted aspects of intelligence in central midfield performance. This encompasses tactical behavior, decision-making quality, and positional awareness under pressure in elite-level football. As a result, the analysis does not focus on purely quantitative performance data but rather on player intelligence, which can be essential for the central midfielder role but not always reflected in raw statistics. Using concepts such as perception–action coupling, scanning, tempo, pressure and positioning to understand how top players see the game and behave consistently during matches. Analysts looked for patterns of play instead of singular actions (Roca et al. 2013).

Six Players were chosen due to their ability to perform at the highest level for an extended period of time and playing as a CM consistently in a possession-based style of play. These Players are Xavi Hernández, Andrés Iniesta, Andrea Pirlo, Sergio Busquets, Luka Modrić, Pedri, and Vitinha. Three full matches from each player were chosen from the UEFA Champions League, domestic league matches, and international competition between the years 2010 and 2024. Giving us 21 full matches to analyze.

Videos of full matches were analyzed by watching and categorizing each moment using sport-specific observation categories based on previous perceptual–cognitive research.

Categories analysts measured included: how often did the player scan their environment before receiving the ball, how quickly did they make decisions when under pressure, what types of passes did they pick out based on the situation they were in, how did they manipulate tempo, and where were they positioned relative to the play. Each full game was watched twice to ensure reliability. All conclusions were able to be drawn because these players exhibited the described behaviors multiple times during the games analyzed. Please keep the limitations of this being a qualitative study with a small sample of elite players in mind.

## The Qualitative Tactical Analysis

The main methodology applied in the process was the qualitative tactical analysis of game footage of elite central midfielders. The selected matches took place at the highest level of domestic and international club competitions, providing a high level of tactical sophistication and consistency in game requirements. Tactical analysis focused on central midfield behavior during different phases of play, such as build-up play organization, defensive transition, maintaining possession, and resisting pressing. In particular, attention was paid to positioning and movement in relation to teammates and opponents, response to pressure, and control of the game's tempo through passing choices and movement off the ball.

## Counterarguments and Contextual Constraints

Although this paper focusses on perceptual–cognitive intelligence as the primary separator of great midfielders from other players, physical traits are still valuable at the requisite level in certain tactical systems and/or leagues that place a premium on pressing or transitional play; in these systems or leagues, more sprint distance covered, won duels, and physicality may be required. This is evidenced by players like Patrick Vieira and Yaya Touré who possessed great physicality while maintaining high levels of tactical intelligence. As such, intelligence is not something that should be traded for athleticism.

## Player Selection Criteria

The players under analysis (Xavi Hernández, Andrés Iniesta, Andrea Pirlo, Sergio Busquets, Luka Modrić, Pedri, Vitinha) were selected based on three main criteria. The first is that the players occupied a constant tactical position in a top-team setup with clear positional responsibilities in structured and possession-based tactics. The second is that the players were in the central areas of the field, and their primary role was tempo management and progression, rather than box-to-box coverage or defensive midfield. The third criterion is that these players are often described by coaches, analysts, and football literature as intelligence-based midfielders whose impact is not always measured by physical and athletic characteristics. This allowed for a sufficient comparison between players in different tactical systems, leagues, and eras while maintaining a consistent focus on the position and the impact of intelligence (Helsen et al. 2005).

## Analytical Dimensions

For the intelligence evaluation of central midfielders, the players were analyzed based on several qualitative parameters. These include the spatial sense of the field, scanning and awareness, speed of decision-making under pressure, pass selection, positional discipline, and anticipation in the defensive phase. The analysis focused less on isolated events but rather on patterns of play over time, for example, the consistency of making the right choices and reducing physical risk through intelligent positioning. Psychological stability and intrinsic motivation contribute significantly to elite performance development (González-Hernández et al. 2023).

In football, the central midfielder is often called the *"*the *"brain"* of the team – and with deep reason. Central midfielders connect defense and attack, dictate the tempo of play, and make countless decisions that shape a match. In fact, *"Central midfield is the nerve centre of any successful team,"* as one analysis aptly put it. There's a famous saying: *if you control the midfield, you control the game.* History shows that great teams nearly always have great central midfielders dictating things from the center. From Xavi and Iniesta in Barcelona's prime, to Andrea Pirlo for Italy and AC Milan, to Luka Modrić, Toni Kroos for Real Madrid– the presence of a top-class midfielder often defines a team's identity and success.

Why is the Central Midfielder so important?

It is the player (or players, since modern teams often employ a pair or trio of central midfielders) who has to do the most varied jobs. They must support the team's defense – by intercepting passes, making tackles, and covering spaces – and also initiate attacking moves by passing forward, switching play, and sometimes scoring or setting up goals themselves. They are quite simply "the perfect all-rounder" on the field. As one coaching article puts it, "Central midfielders are the link between defense and attack… constantly being in position to receive and pass the ball". A team needs a high-quality central midfielder to reinforce its core, who is always ready to receive the ball under pressure and recycle it to a teammate in a better position. The role of central midfielder is the most important. This quality is what allows teams with dominant midfields (think of Spain's World Cup-winning midfield of Xavi-Busquets-Iniesta, or Brazil's great teams) to dominate the game with possession and control matches. It would not be an exaggeration to claim that "your team fails without quality in the middle of the field" – regardless of how good your strikers and defenders are, you need quality in midfield to glue it all together.

And here, crucially, "quality" can take many different forms. A central midfielder does not need to be a strong physical player to do their job well. On the contrary, many of the greatest midfielders have been relatively slight of build and/or slow, but made up for it with exceptional intelligence, technique, and vision. As ESPN put it, "Central midfielders come in all shapes and sizes". Take the example of Sergio Busquets, often dubbed the "metronome" of Barcelona: not particularly fast or physically imposing, yet "keeps Barcelona ticking through astute positioning and sensible distribution". Andrea Pirlo and Xavi Hernández are similar players in this regard, "thriving in relatively deep positions" and concentrating on dictating play through their passing range and football IQ rather than their pace. They are thinking fast and making correct decisions faster than players who has better pace. These players are two steps ahead of the game, reading the play so well that they can position themselves perfectly and pick the right passes to exert complete control over matches.

Of course, there have also been many great midfielders who are more built around physical attributes. Gennaro Gattuso or Roy Keane, for instance, are known for their grit and ball-winning aggression. Or take Patrick Vieira: a huge, towering figure with incredible power, yet also blessed with technical skill and vision. But the important thing is that one can have a top-class central midfielder who thrives almost exclusively on mental attributes and skill. As long as a player has the "brain" for the game – the awareness, vision, and decision-making – they can make up for a lack of size and pace.

The key point is that one can be a top midfielder through mental attributes and skill alone. As long as a player has the "brain" for the game – awareness, vision, decision-making – they can compensate for not being the biggest or fastest.

In fact, such stories are the stuff of football legend: young midfielders who are initially told they are too small and weak to make it at the highest level but then go on to become superstars purely through superior intelligence and technique. A famous case in point is Xavi and Iniesta at Barcelona: "Both players were famously overlooked at the start of their careers because they were too small." Far too many scouts and coaches pigeonholed these lithe, 5'7" playmakers as who would struggle to handle the physical side of the game at top level. But Barca believed in their quality and were handsomely rewarded: Xavi and Iniesta became the heartbeat of a Barcelona team that won multiple Champions Leagues and a Spanish national side that went on to win the World Cup/Euro. Their rise showed the world that skillful ball control, vision, and quick thinking are enough to cut through bigger opponents. As Xavi himself put it, "Football has reached an incredible level of physical development… but I believe we have reached a limit of physical development… the side of talent, as well as technical and tactical knowledge, is where we can still improve. Talent is what makes the difference in a match… the decisive factor is not players with physical presence, but those who give meaning and structure to the game.". Xavi, one of the greatest midfielders ever, openly declaring that football intelligence and natural ability will never be completely trumped by athleticism.

To reinforce Xavi's point: consider Luka Modrić, who led Real Madrid to multiple European titles and won the 2018 Ballon d'Or (World Player of the Year). Modrić stands at only 1.72m (5'8") and isn't exceptionally fast, yet he's widely regarded as one of the best midfielders of his generation. Why? Because of his sublime technique and extraordinary football brain. Modrić once said, *"Football is a game that is played with the head. You can put all the physical strength you want, but there is something called football intelligence… The physical will never supplant the intelligence."*. This quote from a modern great encapsulates the ethos shared by the likes of Xavi, Pirlo, and others – what truly sets elite midfielders apart is their mental sharpness and understanding of the game. They know where to be on the pitch, when to speed up or slow down play, and how to make the correct decision under pressure. Their awareness and vision allow them to see passes that others don't, and their composure allows them to execute those passes even in high-stakes moments.

Real-world examples of central midfielders who succeeded through brain over brawn:

- *Xavi Hernández* – Xavi was the strategic brain of Barcelona. He stands around 5'7" and was never an elite sprinter, but his vision and game understanding were second to none. Xavi could constantly find space to receive the ball, looking around,scanning the position and knew how to bypass entire defenses with one slip pass. His decision-making and one-touch play set the rhythm for his team. As mentioned, despite early doubts about his size, he became a legend by out-thinking opponents. Outcome: 4 Champions League titles and a World Cup, 2 Euros, all built on *mind, not muscle.*
- *Andrés Iniesta* – Xavi's midfield partner, similarly modest in stature, with sublime close control and creativity. Iniesta's high game IQ and **unique** technique allowed him to glide past opponents in midfield, but it was his game intelligence – knowing when to dribble, when to pass, where to open space and his knack for scoring clutch goals – that made him invaluable. He famously scored the last-minute goal against Chelsea and the winning goal in the 2010 World Cup final a testament to his calm mentality under pressure.
- *Andrea Pirlo* – Nicknamed "Il Maestro," Pirlo is an iconic example of a player who "doesn't tackle, doesn't sprint, yet dominated midfields. Lacking pace and not being very physical, Pirlo reinvented himself as a deep-lying playmaker (regista). He would drop near his defenders, orchestrate play with 40-yard passes, free-kicks, and through-balls. His quote *"Football is played with the head, your feet are just the tools"* is legendary, emphasizing that thinking is a footballer's main job. Pirlo's ability to dictate a game's tempo with his mind and technique helped Italy win the 2006 World Cup and AC Milan, Juventus to multiple trophies.
- *Sergio Busquets* – A defensive midfielder who exemplifies game intelligence. Busquets isn't fast or physically strong by typical standards, but his positional sense is so acute that he always seems to be in the right spot to intercept passes or provide an outlet for teammates. He operates almost like a chess player, has an enormous impact on the game, anticipating opponents' moves. It's often said that *"you won't notice Busquets unless you watch closely,"* because he does the simple things perfectly – one-touch passes, opening passing lanes, and maintaining team structure. Coaches and players have lauded him as one of the smartest players in football, and he has been a backbone for Barcelona and Spain for over a decade.
- *Luka Modrić* – As discussed, Modrić uses agility and quick thinking over brute force. Even in his mid-30s, he was outplaying younger, faster players because his understanding of space and timing is superb. He knows how to create angles to receive the ball and can wriggle out of tight spaces with a drop of the shoulder. His endurance is excellent (a reminder that fitness matters too), but it's his decision-making – when to carry the ball forward, when to make a killer pass, when to help defensively – that makes him extraordinary.
- *Pedri* (Barcelona) and *Vitinha* (Paris Saint-Germain) – These are young midfielders who represent the next generation of the "smart, technical midfielder." Pedri, at just 22, has been praised for a football IQ beyond his years – always making the right pass and barely losing possession. *"It's true I don't have the physical build of some stronger players, but I try to compensate*

*in other ways,"* Pedri has noted. He relies on skill, agility, and clever movement rather than outmuscling opponents. Vitinha, similarly, is a relatively small, creative midfielder who excels at pass-and-move football with incredible technique. His national team coach Roberto Martinez explained that Vitinha *"is at the heart of PSG's in-possession game"*, highlighting his technical role and importance in dictating play. These examples show that even as the sport evolves, there is still a place for the cerebral playmaker.

- *Fernandinho* – Unlike the others, Fernandinho (formerly of Manchester City) is a bit more physical, but he's worth mentioning because he demonstrated how intelligence amplifies a midfielder's impact. As a defensive midfielder in his 30s, Fernandinho wasn't the quickest, but he used his experience and reading of the game to break up attacks and start his team's own moves. He was often described as the "shield" for City's defense and the launchpad for attack. His *positional discipline and leadership* made City's midfield balanced and showed that even a more defensive-minded CM relies on footballing IQ (knowing when to foul tactically, how to cover spaces, etc.). His IQ even made him to play as a central defender, without being too fast he was able to play incredibly as a central defender as well.

This variety of examples underlines that young players who are smart and technically skilled should never be discouraged by not being the strongest or fastest. Of course, having pace, power, and stamina is an advantage – modern midfielders do run a lot (the role often demands the highest distance covered in a match). But physical attributes can be developed over time (through training, nutrition, etc.), whereas football intelligence is a unique asset that can set a player apart. Many youth systems today are recognizing this: they look for players with good decision-making and ball control, not just those who win every sprint at age 15. Sadly, as Cruyff lamented, some talented youths have been rejected because they weren't big or strong at a young age – *"I find it terrible when talents are rejected based on computer stats… When I was 15, I couldn't kick a ball 15 meters with my left… My qualities, technique and vision, are not detectable by a computer."*. This is a powerful reminder that vision and game understanding often manifest in ways that raw data (like sprint speed or shot power) won't capture. A player who might be lightweight in their teens could still become the next Modrić or Xavi if nurtured properly.

> For young central midfielders reading this: the message is clear. Cultivate your mind and technique. Study the game, learn from the masters mentioned above, and improve skills like first touch, passing, awareness of your surroundings, and anticipation. If you are a smaller or less physically dominant player, don't be discouraged – focus on being "two steps ahead" in thought. As Cruyff said: *"Football is a game you play with your mind"*. A quick thinker can often beat a quick runner by positioning themselves smartly or executing a perfect pass. And when you do work on physical aspects (which are still important for endurance and injury prevention), remember that it's the combination of brain *and* body that makes a top player. A quote often attributed to various coaches states that *"hard work beats talent when talent doesn't work hard."* So, the ideal is to be talented and work hard – use your intelligence, but also train your body to its best potential. However, never think that you can't succeed just because you're not built like a

typical athlete. The success of so many “undersized” midfield legends proves that football has ample room for the clever playmaker or deep thinker (Modrić 2018).

## Implications for Youth Development and Scouting

*Limitations of Current Talent Identification Models*

The current football scouting culture and infrastructure that is usually employed at youth levels is heavily based on selecting the players who display the most potential to outperform their peers, which is strongly based on physical attributes, including speed, strength, and stamina, among others. This sort of approach poses a structural handicap when it comes to the role of the central midfielder, as it is easy to overvalue the presence of physical superiority over the presence of on-field intelligence, creativity, and decision-making. It is not difficult to find players that would fall under this criteria of having shown potential and skill on the ball during their adolescence but not being able to physically outplay their opponents, being demoted from their position due to poor performance while a physically superior player is chosen to fill their role, causing this type of intelligent playmakers to be either filtered out of the system or to be chosen for a less prestigious position where their play style is better suited for, which causes a major variety in midfield type players to be less in the long run. Proof of this notion can be found in past world-class midfielders such as Xavi Hernández, Andrés Iniesta, or Luka Modrić, who would not have been considered elite by these parameters due to a lack of physical dominance in their positions, instead being outshone by players who had a less intelligent disposition but were physically superior in their roles (Honigshtein 2014).

## Reframing Evaluation Criteria for Central Midfielders

To mitigate these biases, scouting and player evaluation models must adapt to incorporate these cognitive and tactical attributes more prominently. Intelligence-based metrics for central midfielders could include the frequency of scanning before the ball is received, the consistency of correct decisions under pressure, adherence to optimal positions during both attacking and defensive transitions, and spatial manipulation with minimal touches. Evaluators should also assess the extent to which players elevate the performance of those around them. Intelligent midfielders often enhance team performance by providing continuous passing options, maintaining team balance, and orchestrating transitions. These qualities might not be as visible in traditional metrics but are indicative of proficient midfield play. By integrating qualitative observation with quantitative analysis, scouts and coaches can form a more holistic view of a player’s potential.

## Counterarguments and Contextual Constraints

While this study emphasizes cognitive and technical intelligence as central to elite midfield success, physical dominance remains relevant in specific tactical environments. Pressing-intensive systems, transition-heavy leagues, and lower-division competitions may place greater emphasis on sprint capacity, duel success, and high-intensity running metrics. Players such as Patrick Vieira and Yaya Touré exemplify hybrid profiles combining physical power with tactical intelligence. Therefore, intelligence should not be viewed as a replacement for physical capacity but as a differentiating factor once baseline athletic requirements are met.

## Practical Recommendations for Youth Academies

Youth academies have a pivotal role in how the intelligence of a midfielder is nurtured and valued. Training regimes should prioritize enhancing players' perception, decision-making abilities, and tactical understanding rather than focusing solely on physical output and metrics. Small-sided games, positional rondos, and constraint-based games are excellent methods to force increased decision-making and limit the opportunity to outplay an opponent physically.

Video analysis and structured reflection sessions can also significantly contribute to developing these cognitive skills by allowing players to recognize patterns, understand positioning, and assess the outcomes of their decisions. Encouraging players to articulate their decision-making process can help strengthen the connection between perception and action. Crucially, the physical development of young players must be viewed as a long-term process, providing technically and cognitively inclined players sufficient time to develop physically without being sidelined or pushed out of the game prematurely.

Prioritizing intelligence in player development, alongside physical attributes, allows academies to create a more inclusive and effective development pathway. This approach not only increases the chances of producing world-class central midfielders but also ensures player development is more closely aligned with the tactical realities of the modern game (Planet training).

## Discussion, Limitations, and Future Research

The review of play confirms that central midfielders do show signs of intelligence-led play by dictating play and tempo with good positioning, scanning and calmness under pressure. The research in this work would suggest this is how a top-class central midfielder should play, this is also what I have come across in the work of coaches tactically and in terms of game plans within top teams at an elite level.

To reiterate there are some issues with this study, it uses small samples, and there could be more precise and wider evidence for central midfielders not fitting the description, therefore a larger quantitative analysis would help to improve the findings and analysis of this study. This is only one tactical view of central midfielders and with time as one progresses as a coach, the list will only develop and grow. However, this tactical review has been put forward in order to give a qualitative overview of how top-level central midfielders play at the moment and is by no means the be-all and end-all.

For the same reasons this tactical review only focused on central midfielders in the top level and lower down the football ladder, the playing styles and constraints such as physical attributes on development can change. Future research can follow groups of central midfielders as they develop as footballers, as well as a range of metrics could be utilized to increase understanding of intelligence in the position.

With the advent of AI and machine learning, these could be used to scout for more technical and tactical aspects such as scanning, passing decisions and positional heat-maps within games to find recurring trends within these central midfielders.

Performance in elite level central midfield appears linked to perceptual–cognitive skill, particularly scanning behavior, anticipation & tempo. Physical attributes do play a role in performance namely sprint ability & strength in duels but intelligent positioning often negates physical reactive actions. Research supports ideas from perceptual–cognitive expertise literature (Mann et al. 2007) and ecological dynamics frameworks (Araújo et al. 2006). Limitations of generalizability are present due to qualitative methodology. Future studies should utilize mixed-methods to compare notational analysis, GPS-based physical data and longitudinal development.

## Conclusion

In conclusion, elite central midfield performance appears closely linked to perceptual–cognitive expertise and technical execution. While physical capacity remains important, intelligence-driven positioning and decision-making consistently differentiate elite performers. These findings reinforce the need for cognitively informed scouting and development frameworks in modern football.

## References

Aksum KM, Sevimli D, Flaten V, Bjørndal CT, Helsen WF (2021) Scanning activity of elite football players in 11 vs. 11 match play. *PLOS ONE*, 16(1), e0244118. https://doi.org/10.1371/journal.pone.0244118

Araújo D, Davids K, Hristovski R (2006) The ecological dynamics of decision making in sport. *Psychology of Sport and Exercise,* 7(6), 653–676. https://doi.org/10.1016/j.psychsport.2006.07.002

Cobley S, Baker J, Wattie N, McKenna J (2009) Annual age-grouping and athlete development: A meta-analytical review of relative age effects in sport. *Sports Medicine*, 39(3), 235–256. https://doi.org/10.2165/00007256-200939030-00005

Hernández X (2018) *Xavi on talent, intelligence, and the limits of physical development in football* [Interview]. ESPN FC. https://www.espn.com

ESPN (n.d.) *Why the midfield is football's engine room. ESPN FC.* https://www.espn.com

Modrić L (2018) *Football is played with the head: Intelligence over physical strength* [Interview]. FIFA.com. https://www.fifa.com

González-Hernández J, Gómez-López M, Manzano-Sánchez D, Valero-Valenzuela A (2023) Motivated and without fear of failure: The strength of basic psychological needs in youth Spanish athletes in team sports. *Journal of Human Kinetics*, 87, 235–245. https://doi.org/ 10.5114/jhk/162449

Helsen WF, Van Winckel J, Williams AM (2005) The relative age effect in youth soccer across Europe. *Journal of Sports Sciences*, 23(6), 629–636. https://doi.org/10.1080/02 640410400021310

Planet Training (n.d.) *Central midfielder: The perfect all-rounder.* Planet Training. https://www. planettraining.com

Honigstein R (2014) *Pep confidential: The inside story of Pep Guardiola's first season at Bayern Munich*. BackPage Press.

Mann DTY, Williams AM, Ward P, Janelle CM (2007) Perceptual-cognitive expertise in sport: A meta-analysis. *Journal of Sport & Exercise Psychology*, 29(4), 457–478. https://doi.org/10.1123/jsep.29.4.457

McGuckian TB, Cole MH, Jordet G (2018) Don't turn blind! The relationship between exploration behavior and match performance in football. *Frontiers in Psychology,* 9, 2520. https://doi.org/10.3389/fpsyg.2018.02520

Roca A, Ford PR, McRobert AP, Williams AM (2013) Perceptual-cognitive skills and their interaction as a function of task constraints in soccer. *Journal of Sport & Exercise Psychology*, 35(2), 144–155.

Vaeyens R, Lenoir M, Williams AM, Philippaerts RM (2008). Talent identification and development programmes in sport: Current models and future directions. *Sports Medicine*, 38, 703–714. https://doi.org/10.2165/00007256-200838090-00001