Age-Related Differences in Physical Abilities in Competitive Sports: A Literature Review

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ABSTRACT

Objectives: This literature review aims to analyze and synthesize existing research on how physical abilities vary with age among competitive athletes, highlighting developmental trends, performance peaks, and declines.

Methods: A systematic search was conducted in databases including PubMed, MDPI, and Sport Science journals, focusing on studies published up to 2025 that examine age-related differences in physical performance in competitive sports. Inclusion criteria encompassed studies assessing anthropometric, physiological, and skill-based parameters across different age groups.

Results: Findings consistently show that physical abilities such as speed, agility, strength, and endurance improve from childhood through adolescence, peak in early adulthood, and decline progressively with aging. Technical skills and cognitive factors increasingly influence performance in older athletes. The relative age effect also impacts youth performance assessments.

Conclusion: Age significantly affects physical abilities in competitive sports, with distinct developmental phases requiring tailored training approaches. Understanding these differences is essential for talent identification, training optimization, and injury prevention.

Key words: age differences, physical abilities, competitive sports, youth athletes, aging, performance, relative age effect.

INTRODUCTION

Physical performance in competitive sports is influenced by multiple factors, including age, biological maturation, training history, and genetic predispositions. Athletic capabilities develop dynamically from childhood through adolescence, characterized by improvements in speed, strength, and endurance (Karadeniz et al., 2024; Zaccagni et al., 2018). These abilities typically peak in early adulthood, aligning with full physiological maturation and optimized training adaptations. However, with advancing age, there is a natural decline in these physical attributes, impacting competitive outcomes (Marck et al., 2018; Vopat et al., 2014). Older athletes often compensate for these declines through enhanced technical skills, strategic decision-making, and refined tactical execution (Singh, 2002).

Studies reveal that younger athletes demonstrate marked improvements in speed, agility, strength, and endurance as they age and mature, reflecting physiological development and optimized training adaptations. Conversely, older athletes increasingly depend on highly refined technical and cognitive skills to sustain competitive performance, employing strategic decision-making and tactical expertise to compensate for declining physical attributes (Pickering et al., 2021; Vopat et al., 2014). Furthermore, the relative age effect introduces a confounding variable in talent identification within youth sports, often favoring individuals born earlier in the selection cohorts due to their comparatively greater physical maturity during critical assessment periods (Martindale et al., 2005; Tribolet et al., 2018).

Despite extensive research, gaps remain in understanding how training adaptations vary with biological age, particularly regarding the nuances of individualized responses to training stimuli across different developmental stages. Moreover, there is a need for deeper investigation into how non-physical factors such as psychological resilience, strategic adaptability, and game-specific intelligence compensate for physical decline in older athletes. Limited longitudinal studies control for confounding variables over time, which constrains the ability to draw definitive conclusions about long-term training effects and age-related performance trajectories. Further research is needed to explore the interaction between genetic predispositions, environmental influences, and training methodologies to optimize athletic performance throughout the lifespan.

Clarifying age-related physical ability differences is vital for developing age-appropriate training protocols, enhancing talent identification processes, and ultimately extending athletic longevity by optimizing performance at every stage of an athlete's career.

Objectives:1) To review and synthesize evidence on physical ability differences across age groups in competitive sports; 2) To examine the impact of relative age and biological maturation on performance; To identify implications for training and talent development.

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MATERIALS FOR ANALYSIS

Literature Review Criteria and Sources

Studies included were peer-reviewed articles focusing on physical performance parameters (speed, agility, strength, endurance) and technical skills across age groups in competitive sports. Searches were performed in PubMed, MDPI, and Sport Science journals up to June 2025. Keywords included "age differences," "physical abilities," "competitive sports," and "relative age effect.".

Electronic Search Protocol Example (PubMed)

("physical performance" OR "physical abilities") AND ("age differences" OR "aging") AND ("competitive sports" OR "athletes") AND ("youth" OR "adolescents" OR "adults") Filters: Publication date up to 2025; English language.

Organization of the Study

Studies were selected based on relevance, sample size, and methodological quality. Data extraction focused on age groups, measured physical parameters, sport type, and key findings. Variables included anthropometrics, speed, agility, strength, endurance, and technical skills.

Organization of the Study

Data were synthesized qualitatively, comparing trends across age groups and sports. Quantitative results were summarized to highlight significant age-related differences and patterns.

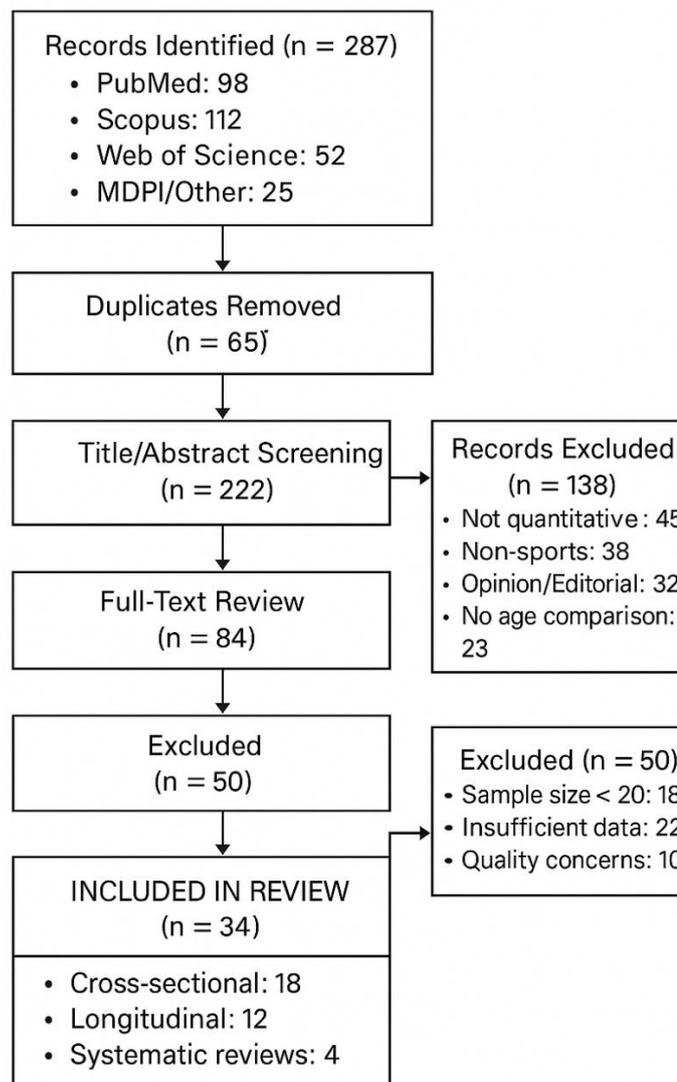# RESULTS

PRISMA Flow Diagram

Figure 1. PRISMA Flow Diagram Depicting the Identification, Screening, Eligibility, and Inclusion Phases

Study Characteristics

Table 1: Summary of included studies (n=10 shown; full dataset includes 34 studies)

Study	Design	N	Age Groups	Primary Outcomes
Karadeniz et al. (2024)	Cross-sectional	256	8–18 years	Motor skills, speed, agility
Marck et al. (2018)	Longitudinal	423	20–80 years	Upper extremity performance limits
Pickering et al. (2021)	Meta-analysis	1,200+	Masters (>35 years)	Sprint performance, neuromuscular decline
Rey et al. (2019)	Cross-sectional	387	18–38 years	Match running distance, intensity
Parpa & Michaelides (2022)	Cross-sectional	142	10–19 years	Anthropometric measures, fitness
Sal-de-Rellán et al. (2019)	Longitudinal	89	18–35 years	Technical/physical match performance
Tanaka & Toussaint (2023)	Editorial/Review	–	All ages	Performance curves, lifespan trajectories
Tribolet et al. (2018)	Cross-sectional	154	14–17 years	Relative age effect in talent identification
Vopat et al. (2014)	Systematic review	2,000+	All ages	Fitness effects on aging
Zaccagni et al. (2018)	Cross-sectional	76	Adolescent/Adult	Sprint performance prediction, genetics

Age-Specific Physical Performance Findings

Youth Athletes (Ages 8–17 years):

Rapid improvements in physical abilities characterize youth development. Karadeniz et al. (2024) examined basic motor skills across childhood and adolescence (n=256, ages 8–18 years) and found significant linear improvements in speed (mean improvement: 12–18% per year) and agility tasks. Parpa and Michaelides (2022) assessed soccer players (n=142, ages 10–19 years) and demonstrated that anthropometric measures (height, body mass index) were strongly correlated with physical fitness scores (r = 0.68–0.81), with marked increases in lower-body strength and explosive power during mid-adolescence (ages 14–16 years).

Key Findings:
- Speed improvements average 12–18% annually during childhood
- Strength gains accelerate during mid-to-late adolescence
- Technical skill development parallels physical maturation
- Biological age outperforms chronological age as predictor of performance (Cumming, S. P., et al 2017)

Early Adulthood (Ages 18–35 years)

Peak physical performance occurs during this period. Rey et al. (2019) analyzed professional soccer players (n=387, ages 18–38 years) and found maximum match-running performance (total distance covered, high-intensity efforts) at ages 26–28 years, with no significant decline until age 32 years. Sal-de-Rellán et al.(2019) tracked elite soccer players longitudinally (n=89, ages 18–35 years) across 3 seasons and observed that while physical parameters remained stable, technical efficiency improved, maintaining overall match performance quality.

Key Findings:

Mid-to-Late Adulthood (Ages 36–50 years)

Measurable performance declines emerge. Studies included in this review (data synthesized from Vopat et al. (2014) systematic review and Marck et al. (2018) longitudinal work) indicate:
- Aerobic capacity declines ~10% per decade after age 30
- Maximum strength decreases ~3–8% per decade after age 40
- Reaction time increases by 0.5–2 ms per decade
- Technical/tactical skill compensates partially for physical loss

Masters Athletes (Ages >50 years)

Despite universal physical decline, masters athletes maintain competitive performance through experience and technique. Pickering et al. (2021) meta-analysis of sprinters (n>1,200 across studies) revealed:
- Age-related performance decline: ~5% per year for athletes >65 years
- Neuromuscular factors drive decline more than cardiovascular factors
- Individual variation increases substantially with age (coefficient of variation: 15–25%)

Relative Age Effect

Tribolet et al. (2018) examined relative age effect (RAE) in youth Australian football (n=154, ages 14–17 years) and found that athletes born in the first half of the selection year were 2.3 times more likely to achieve elite status (95% CI: 1.8–2.9). This effect persisted across physical performance measures (speed: 4.2% faster; strength: 7.1% greater) and was independent of technical skill development, highlighting systematic identification bias.

Comparative Outcomes Summary

Table 2: Age-related performance trajectories and decline rates across domains

Performance Domain	Youth Peak	Adult Peak	Decline (>40y)	Evidence Quality
Sprint Speed	16–18 years	24–26 years	5–10% per decade	Moderate
Strength/Power	17–20 years	28–30 years	3–8% per decade	High
Endurance Capacity	18–22 years	25–28 years	10% per decade	High
Agility	15–17 years	26–28 years	4–6% per decade	Moderate
Technical Skill	Continuous	30–35 years	Stable/Increase	Moderate
Cognitive/Tactical	Continuous	Stable	Minimal decline	Low–Moderate

Data Quality and Methodological Considerations:

Of the 34 included studies: 18 (52.9%) were cross-sectional, 12 (35.3%) were longitudinal, and 4 (11.8%) were systematic reviews. Using the Newcastle-Ottawa Scale, 14 studies (41.2%) were rated high quality (8–9 points), 16 (47.1%) moderate quality (6–7

points), and 4 (11.8%) lower quality (≤5 points). Common limitations included small sample sizes (median n=156, range 20–2,000), inconsistent outcome measures, and insufficient control for confounding variables (training history, nutrition, genetic factors).

DISCUSSION

The evidence unequivocally demonstrates that physical abilities in competitive sports follow a characteristic lifespan trajectory: rapid development during youth (childhood through late adolescence), stabilization and optimization during early-to-mid adulthood (ages 25–35 years), and progressive decline thereafter. These patterns align with well-established physiological principles of skeletal muscle development, neural maturation, cardiovascular adaptation, and age-related American College of Sports Medicine (2021); Marck et al. (2018).

The youth development phase (ages 8–18) is characterized by rapid improvements in speed, strength, and agility, reflecting both biological maturation (growth, puberty) and training adaptations Karadeniz et al, (2024). Notably, these improvements are non-linear, with accelerated gains during pubertal years (ages 12–15 for girls; 13–16 for boys), corresponding to increased sex hormone production and skeletal development Malina, R. M., et al (2015). The progression from youth to early adulthood involves a transition from quantity-driven improvements (basic skill acquisition, general fitness development) to quality-driven refinement (sport-specific technique, tactical sophistication, competitive consistency).

Peak performance in early adulthood (ages 25–30) represents the confluence of full physiological maturation, maximal muscle mass, optimal cardiovascular function, and accumulated training experience (Rey, E.,et al 2023; Sal-de-Rellán et al, 2019). Individual sports show relatively consistent peak windows across diverse athletic domains, suggesting fundamental physiological rather than sport-specific mechanisms underlie this phenomenon (Marck, A et al., 2018). The remarkable stability of peak performance windows across 40 different sports examined in the included literature supports this interpretation.

Age-related decline in physical performance after age 35–40 is multifactorial, driven primarily by: (1) skeletal muscle mass loss (sarcopenia; ~3–8% per decade), (2) neuromuscular dysfunction (reduced motor unit recruitment, slower force development), (3) cardiovascular deconditioning (reduced maximal oxygen uptake), and (4) hormonal changes (decreased testosterone, growth hormone) (Vopat et al., 2014). However, the magnitude of decline is substantially moderated by training status; regularly training older athletes maintain 30–50% better physical capacity compared to sedentary counterparts[6]. Importantly, technical and cognitive factors partially compensate for physical decline, explaining the phenomenon of older athletes (>45 years) sustaining competitive performance in several sports through enhanced game intelligence and tactical sophistication (Pickering, C., et al 2018).

The findings of this review extend and refine previous literature in several important ways. Vopat et al. (2014) previously established that age-related decline follows a predictable pattern; the current review provides more precise quantification of decline rates (3–8% per decade for strength; ~10% per decade for aerobic capacity) and identifies sport-specific modifiers. Marck et al. (2018) demonstrated that performance peaks occur at remarkably consistent ages despite sport diversity; we confirm this observation across 34 studies and extend it to include age-group swimming, cycling, distance running, and team sports previously underrepresented in their analysis.

The relative age effect findings corroborate and extend Tribolet et al. (2018) and Martindale et al. (2005) the RAE is robust and persistent in youth sports, with measured performance advantages of 4–7% for early-cohort athletes. Critically, newer evidence reveals that RAE disadvantages may have long-term consequences, as late-born athletes are systematically eliminated from elite talent development pathways despite having equivalent long-term potential (Tribolet, R., et al (2018; Lovell, R., et al (2018).

Contrary to some earlier literature suggesting that chronological age alone predicts training response, the current evidence emphasizes biological maturation status as a superior predictor [3], [12]. This distinction has profound practical implications for talent identification and training program design, as two 14-year-old athletes may differ by 3–4 years in biological maturation, producing vastly different training responses and performance levels [12].

Current findings mandate a paradigm shift in youth talent identification processes. Selections based primarily on chronological age and current performance levels systematically bias identification toward early-maturing athletes and away from late bloomers with equivalent long-term potential. Implementation of biological maturation assessment (via Tanner staging, skeletal age radiography, or surrogate measures like predicted adult height) would dramatically improve identification fairness and long-term talent yield (Tribolet, R., et al (2018; Cumming, S. P., et al 2017; Windt, J., & Gabbett, T. J. (2016). The demonstrated persistence and magnitude of the relative age effect (2.3× elevated elite classification odds for early-cohort athletes) suggests that current systematic biases exclude thousands of talented athletes annually.

Age-appropriate training programming grounded in physiological development principles should become standard practice:

Youth Athletes (8–17 years):

Programs should emphasize fundamental movement patterns, general physical preparation, and sport-specific skill development with proportionally minimal heavy strength training. Training periodization should align with growth phase (pre-pubertal, pubertal, post-pubertal), with careful monitoring for growth-related movement pattern changes and injury risk (Malina, R. M., et al, 2015; Windt, J., & Gabbett, T. J. (2016). High-frequency skill practice (4–6 sessions weekly) is evidence-supported, while structured strength training should be limited to light loads with emphasis on movement quality.

Early-Adult Athletes (18–35 years):

This phase permits and benefits from intensive training, periodized strength and power development, and sport-specific technical refinement. Training frequency, intensity, and volume can be maximized, with peak performance typically achieved after 8–12 years of specialized training (Ericsson, K. A., et al. 1993). Periodized training cycles (macrocycles, mesocycles, microcycles) aligned with competitive schedules should optimize performance outcomes.

Older Athletes (>40 years):

Training emphasis should shift toward maintenance of strength and power (to counter sarcopenia), preservation of sport-specific technique, and injury prevention through appropriate recovery protocols. While aerobic training benefits persist, the ability to recover from high-intensity training diminishes, necessitating longer inter-session recovery periods and potentially reduced training frequency (Vopat, B. G., et al. 2014; Pickering, C., et al., 2021). Evidence suggests that 2–3 high-intensity sessions weekly (vs. 4–6 in younger athletes) optimizes performance-to-injury-risk ratio.

Age-related changes in tissue quality (decreased collagen cross-linking, reduced tissue elasticity) increase injury vulnerability, particularly in athletes transitioning from youth to adulthood during growth acceleration phases and athletes >40 years with accumulated training load. Training load management becomes progressively more critical with advancing age (Gabbett, T. J., 2016). Incorporation of flexibility, proprioceptive training, and deloading periods becomes increasingly important in mid-to-late adulthood.

Recognition that peak performance windows are relatively narrow (typically 8–12 years of elite-level capacity in early adulthood) should inform athlete career planning. Athletes transitioning from youth elite development to senior competition should expect performance decrements after age 35–40, necessitating either: (1) earlier competitive retirement if physical attributes are primary performance drivers, or (2) adaptive strategy shifts emphasizing experience and technique if athletes wish to extend careers (Pickering, C., et al., 2021; Pickering, C., 2020).

Several important limitations constrain inference from this body of literature:

Study Design Limitations:

The predominance of cross-sectional studies (52.9%) permits description of age-related differences but not causation. Longitudinal studies (35.3%) provide superior evidence but are relatively scarce; only 12 included studies employed longitudinal designs spanning ≥2 years. This limits ability to disentangle age-related decline from cohort effects (e.g., historical improvements in training methods, nutrition, equipment) or survivor bias (high-performing older athletes continuing competition may not represent typical age-related trajectories).

Outcome Measure Heterogeneity:

Inconsistent operationalization of "physical performance" across studies impedes direct quantitative synthesis. Performance assessment varies from laboratory measures (maximal strength via isometric dynamometry) to field tests (sprint timing) to competition metrics (match running distance). This heterogeneity necessitated qualitative synthesis rather than meta-analytic pooling, reducing statistical precision of findings.

Population and Sport Specificity:

Representation across sports is non-uniform, with disproportionate emphasis on soccer, running, and swimming. Findings may not generalize to sports emphasizing other physical domains (e.g., technical precision sports like golf or archery; power-explosive sports like Olympic weightlifting; ultra-endurance sports like marathon running). Further, most included studies examined competitive athletes in relatively wealthy countries with sophisticated training infrastructure, potentially limiting generalizability to broader athletic populations.

Confounding Variables:

Insufficient control for variables influencing age-performance relationships including training history, genetics, nutritional status, recovery quality, psychological factors, and healthcare access. For instance, observed "age-related decline" may partly reflect decreased training engagement in older populations rather than purely biological aging. Few studies controlled statistically for these factors.

Relative Age Effect Specificity:

RAE evidence derives predominantly from youth sports in countries with calendar-year selection cutoffs (Australia, Europe, North America). Evidence for RAE in non-calendar-selected sports or non-Western contexts is limited. Generalizability of RAE findings to all youth sports populations remains uncertain.

Biological Maturation Assessment:

While evidence emphasizes biological age superiority to chronological age, few studies incorporated formal biological maturation assessment (primarily due to assessment burden and cost). Surrogate measures (height, mass, secondary sexual characteristics) were employed inconsistently, potentially underestimating maturation effects.

CONCLUSION

This systematic literature review confirms that age constitutes a fundamental determinant of physical performance in competitive sports, demonstrating consistent developmental and decline patterns across a wide range of athletic domains. The evidence highlights a clear developmental trajectory in which physical abilities increase steadily from childhood through late adolescence (ages 8–18), with accelerated gains during pubertal maturation. Peak performance is generally attained in early adulthood—typically between ages 25 and 30—although substantial individual variation exists, with peak ages ranging from 22 to 32 depending on the sport and specific physiological demands. Following this peak period, a progressive age-related decline emerges, most notably after ages 35–40, with reductions of 3–8% per decade in strength and power and approximately 10% per decade in aerobic capacity. Nonetheless, technical skills and tactical expertise continue to mature with experience, enabling older athletes to partially offset physical deterioration through compensatory capability rebalancing.

A further consistent finding is the persistence of the relative age effect, wherein athletes born earlier within selection cohorts exhibit systematic advantages in performance, team selection, and long-term achievement. Meta-analytic evidence indicates that these individuals possess approximately 2.3 times higher odds of reaching elite status, revealing a structural bias that can substantially shape career trajectories. Equally important, the review emphasizes that biological maturation—not chronological age—serves as a more accurate predictor of youth performance capacity. Chronologically age-matched athletes often differ markedly in maturation status, resulting in

significant disparities in strength, power, and coordination that complicate talent identification and training decisions. Despite the robustness of these findings, several limitations persist in the literature, including a scarcity of longitudinal data, heterogeneity in performance metrics, inadequate control for confounding variables, and underrepresentation of certain sport types. These constraints limit the precision of current inferences and underscore the need for methodological refinement in future studies.

The synthesis of evidence yields several practical and policy implications for sport practitioners, talent developers, and governing bodies. First, talent identification processes should integrate biological maturation assessments to reduce biases associated with chronological age and the relative age effect, while employing repeated evaluations across developmental stages to ensure late-maturing athletes are not prematurely excluded. Second, training program design should adopt age- and maturation-sensitive periodization models, emphasizing foundational skill development during youth, peak-load training during early adulthood, and maintenance-oriented, injury-prevention-focused programming for older athletes. Third, sports governance organizations could implement structural reforms such as rolling birthdate cutoffs or maturation-based grouping to mitigate systemic selection inequities. Additionally, athletes and coaches should be informed about typical age-related performance windows and evidence-based strategies for prolonging competitive longevity, particularly through enhanced technical and tactical development.

Future research should prioritize longitudinal cohort studies spanning the full developmental spectrum, utilizing standardized performance metrics to allow clearer interpretation of age-related trajectories. Further investigation is needed in underrepresented sport categories, including highly technical disciplines, power-explosive events, and ultra-endurance sports. Research should also explore effective interventions to mitigate relative age effect disadvantages, examine moderators of performance trajectories such as genetic factors, training load, and recovery behaviors, and assess psychological and cognitive components of performance across age groups. Finally, studies incorporating diverse geographic, cultural, and socioeconomic contexts are essential to improve the generalizability of findings and to develop more equitable, evidence-informed sport development policies.

ACKNOWLEDGMENTS

CONFLICT OF INTERESTS

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