

A decade of change in Hungarian handball: Structural trends and determinants of youth–senior transition (2013–2023)

CSILLA ILDIKO FILO

University of Pécs, Faculty of Health Science, Institute of Physiotherapy and Sport Science, HUNGARY

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Abstract:

Problem statement: The transition from youth to senior competition represents a critical phase of athlete development, during which increasing performance demands and organisational pressures frequently contribute to dropout. Although Hungarian men's handball has undergone major structural changes and rapid expansion over the past decade, little is known about how individual characteristics, organisational conditions, and system-level reforms jointly shape athletes' progression beyond the youth category. The lack of longitudinal, system-wide evidence limits understanding of the mechanisms influencing retention at this decisive developmental threshold. Therefore, this study examined the multilevel predictors of career continuation versus dropout among male players competing in Hungary's top youth division between 2013 and 2023. **Methods:** A national registry including 2,161 players was analysed, of whom 1,879 athletes with definitive post-youth outcomes were included in multivariable models. Dropout was defined as the absence of any senior-level appearances. Predictors encompassed individual attributes (birth cohort), organisational characteristics (club type and the presence of a senior pathway through NB I or NB I/B teams), and system-level exposure to the post-2017 structural reform. Logistic regression was supplemented by ordinal models, multilevel analyses, and sensitivity tests to assess robustness. **Results:** The dropout rate at the youth–senior transition was 32.3%. Four significant predictors emerged. Players born after 2000 showed markedly higher odds of dropout compared with earlier cohorts. Organisational context was a strong determinant: affiliation with a club providing a direct senior pathway substantially reduced dropout, whereas players from newly established development centres exhibited higher attrition than those from traditional clubs. Independent of these factors, exposure to the post-2017 period—characterised by rapid competition-system expansion—was associated with an increased likelihood of dropout. Cohort size was not a significant predictor. All findings remained stable across robustness checks. **Conclusions:** Youth–senior transition outcomes in Hungarian men's handball are shaped by the combined influence of generational load, organisational maturity, and system-level structural conditions. Stable developmental environments and clear senior progression routes appear essential for supporting athlete retention. To enhance long-term continuity, structural expansion should be aligned with proportional investments in coaching expertise, athlete-support systems, and integrated youth–senior development frameworks.

Keywords: athlete development; youth–senior transition; dropout; organisational maturity; senior-pathway structure; high-performance handball

Introduction

The transition from youth to senior competition represents one of the most critical developmental junctures in long-term athlete development, particularly in performance-oriented team sports. Athlete development frameworks such as the Long-Term Athlete Development (LTAD) model and the Youth Physical Development Model emphasise that late adolescence is a sensitive period in which biological maturation, psychosocial demands, and increasing performance expectations converge (Ford et al., 2011; Lloyd & Oliver, 2012). During this stage, athletes must balance intensified training loads, dense competition schedules, and heightened evaluation pressure with academic responsibilities and ongoing identity formation, making this phase especially vulnerable to dropout and disengagement.

In handball—one of Europe's most systematically organised invasion sports—the youth–senior transition is a decisive step influencing long-term retention, career progression, and national performance potential. International research consistently highlights that elevated training demands, insufficient psychosocial support, and organisational instability contribute to emotional exhaustion, reduced perceived competence, and an increased likelihood of dropout (Gustafsson et al., 2017; Soares & Carvalho, 2023; Wilczyńska et al., 2022). These developmental risks are intensified in high-pressure youth handball environments, where athletes face dense match calendars and dual expectations in school and sport.

The Hungarian handball system offers a particularly relevant case for examining these developmental dynamics. As one of the flagship sports in Hungary, handball benefits from a wide institutional network of clubs, academies, and state-supported development centres. Over the past decade, however, this system has undergone

extensive structural reform, including rapid expansion of youth leagues, the establishment of new development centres, and substantial increases in the number of competing teams. Although these reforms were intended to expand the athlete base and enhance talent development structures, emerging concerns suggest that the pace of expansion may have exceeded the growth of organisational capacity, coaching resources, and athlete-support mechanisms—factors shown to be critical in mitigating burnout and dropout risk (Battaglia et al., 2024; Emmonds et al., 2024).

Existing Hungarian studies have primarily examined psychological or relational components of athlete experience, including coping strategies (Cosma et al., 2020; Ökrös et al., 2020), self-evaluation (Nagy et al., 2018), and coach–athlete relationship quality (Kovács et al., 2021). While these findings offer important insights into determinants of athlete wellbeing, they lack integration with long-term, system-level competition data needed to evaluate structural effects on youth–senior progression. Moreover, there is limited empirical evidence from Central and Eastern European sport ecosystems in the international literature, where developmental structures and resource conditions differ substantially from Western European systems. This gap limits the comparative understanding of how structural reforms and organisational maturity influence athlete retention across diverse handball environments.

The present study addresses this gap by analysing a decade of national competition records from Hungarian male handball players who competed in the top youth division between 2013 and 2023. Using a harmonised longitudinal dataset, the study examines individual, organisational, and system-level factors that may influence career continuation versus dropout at the transition from youth to senior level. Particular attention is given to generational differences in developmental conditions, the organisational maturity of newly established development centres compared with traditional clubs, and the role of clear senior progression pathways—identified as key structural supports in athlete-development models such as FTEM (AIS, n.d.; Morley, 2022). The core problem addressed in this research is as follows: Which individual, organisational, and system-level characteristics predict whether male youth handball players in Hungary continue their athletic careers beyond the youth category, and how are these outcomes shaped by structural reforms introduced during the past decade? To answer this question, the study integrates multilevel determinants—birth cohort effects, club developmental structures, senior pathway availability, and exposure to the post-2017 league expansion—providing a system-wide understanding of youth–senior transition mechanisms within Hungarian handball.

By offering the first longitudinal, structural analysis of youth–senior transition outcomes in this national context, the study contributes to sport science in three major ways: (1) it provides evidence on how generational load and changing competition environments influence dropout risk; (2) it clarifies the impact of organisational maturity and structural pathway visibility on athlete retention; and (3) it evaluates the developmental consequences of rapid system expansion, offering actionable implications for policy-makers, club administrators, and talent-development practitioners seeking to improve long-term athlete progression.

Grounded in the theoretical and empirical considerations above, five hypotheses were formulated:

H1 – Generational Differences in Dropout Risk: Players born after 2000 will show higher dropout rates at the end of the youth age category compared with players born before 2000. Younger cohorts have faced more professionalised, high-load youth environments characterised by increased training demands and elevated performance expectations, conditions consistently linked to heightened burnout and attrition risk.

H2 – Club-Level Structural Predictors of Dropout: Youth players originating from clubs without high-level senior teams (e.g., no NB I or NB I/B representation) will exhibit a greater likelihood of discontinuing their careers compared with players from clubs that provide clear senior-level progression pathways, reflecting FTEM’s emphasis on structurally embedded Talent → Elite transitions.

H3 – Differences Between Traditional and Newly Established Development Centres: Traditional clubs and long-standing handball academies are expected to demonstrate higher talent retention and produce more athletes who progress to upper-tier senior leagues than newly established post-2017 development centres, due to advantages in organisational maturity, coaching stability, and established developmental cultures.

H4 – System-Level Effects of the 2017 Structural Expansion: The 2017 youth-league expansion is hypothesised to increase overall dropout rates, owing to disproportionate growth in competition structures relative to developmental support resources.

H5 – Cohort Size and Competitive Pressure: Larger birth-year cohorts are expected to be associated with higher dropout probability, reflecting intensified internal competition and reduced perceived opportunities for upward mobility.

By embedding these hypotheses within a decade of national registry data, the study provides an empirically grounded examination of how structural, organisational and generational dynamics converge to shape youth–senior transition outcomes in one of Europe’s most intensively supported handball ecosystems.

Material & methods

Study Design and Data Source

This study used a retrospective, longitudinal cohort design to examine youth–senior transition outcomes among male handball players competing in Hungary’s top youth division over ten competitive seasons (2013/14–2022/23). Player-level data—including licensing records, match appearances, club affiliations, and

senior-level registrations—were obtained from publicly accessible databases maintained by the Hungarian Handball Federation (MKSZ). The initial registry contained 4,616 athletes; after data harmonisation and eligibility filtering, 2,334 players met all inclusion criteria for descriptive analyses. Among these, 1,879 players had definitive senior-transition outcomes and were retained for regression modelling, while athletes still active at the youth level in 2022/23 were excluded from inferential analyses to avoid right-censoring but remained in descriptive summaries.

Eligibility Criteria

Players were included if they appeared in at least one official match in the highest youth category (U20/U21) during any season in the study period, had complete information on birth year, club, and season, and reached the transition threshold by the end of 2022/23. Players were excluded if they competed solely in lower youth tiers, lacked critical demographic or club identifiers, or remained active in youth competitions after the 2022/23 season for inferential analyses. After preprocessing, each athlete contributed a single analytic record corresponding to his final youth season.

Outcome Definition

The primary outcome was the highest competitive level attained after the youth category, classified on a seven-tier ordinal scale: NB I (first division), NB I/B (second division), NB II, county/regional senior leagues, international senior league, dropout (zero senior appearances), and active youth player in 2023 (right-censored). For the main regression model, the outcome was dichotomised as dropout versus continuation, with dropout defined as no participation in any domestic or international senior league.

Explanatory Variables

Predictors were selected to reflect individual, organisational, and system-level characteristics relevant to athlete-development contexts. Individual-level variables included birth cohort (pre-2000 vs. post-2000) and birth-year cohort size, operationalised as the number of registered players born in the same year. Club-level variables comprised organisational type, differentiating established, traditional handball academies from newly formed development centres emerging after 2017, and the presence of a senior-pathway opportunity through affiliation with an NB I or NB I/B senior team. System-level exposure to structural change was captured by a period dummy indicating whether a player's final youth season fell before or after the major 2017 youth-league reform.

Data Processing and Quality Control

Data cleaning involved harmonising club names and identifiers across seasons, resolving duplicates, and validating senior-level participation through cross-referencing with adult-league registers. Dropout status was assigned only to athletes with no recorded senior appearances in any competition. Logical integrity checks ensured mutually exclusive outcome categories and consistency across demographic and club variables. All data management procedures were executed using Python (pandas, numpy, statsmodels) in a version-controlled environment.

Statistical Analysis

Descriptive analyses summarised participation patterns, birth-year distributions, and dropout proportions across key subgroups, with χ^2 tests applied to categorical variables and t-tests or non-parametric equivalents used for continuous variables. The primary inferential model was a multivariable logistic regression estimating the adjusted odds of dropout. The model was specified as:

$$\text{logit}(P(\text{Dropout}_i)) = \beta_0 + \beta_1(\text{Post2000}_i) + \beta_2(\text{ClubType}_i) + \beta_3(\text{SeniorPath}_i) + \beta_4(\text{Post2017}_i) + \beta_5(\text{CohortSize}_i) + \varepsilon_i.$$

Diagnostic procedures included assessment of multicollinearity via variance inflation factors, checks for linearity in the log-odds for continuous variables using Box–Tidwell tests, and influence diagnostics based on Cook's distance. Model calibration was evaluated using the Hosmer–Lemeshow test, and predictive discrimination using ROC-curve area.

Robustness and Sensitivity Analyses

Several robustness tests were conducted. First, ordinal logistic regression models were estimated using the full seven-level outcome (excluding or censoring active-youth cases) to examine whether predictors were associated with the likelihood of reaching higher senior tiers. Second, a multilevel logistic regression model with players nested within clubs accounted for potential clustering and quantified between-club variance. Additional sensitivity analyses evaluated alternative cohort definitions, alternative senior-pathway classifications (NB I only vs. NB I + NB I/B), and two extreme cases for handling right-censored players (classifying them all as continuers or all as dropouts). Comparisons were made to assess whether the direction and significance of effects remained stable across specifications.

Missing Data

Missing data were minimal across all variables, and complete-case analysis served as the primary analytic approach. A multiple-imputation framework using chained equations was prespecified for situations where missingness exceeded 5%, but this threshold was not reached.

Ethical Considerations

All data were derived from publicly accessible competition records containing only non-sensitive identifiers. In accordance with institutional guidelines and GDPR provisions governing public sports data, formal ethics approval was not required.

Results

Sample characteristics

After data harmonisation and deduplication, the analytic dataset comprised 2,161 unique male youth handball players who competed in Hungary's top youth division between 2013/14 and 2022/23. Of these, 1,879 athletes had definitive post-youth outcomes (categories 1–6) and were included in inferential analyses, while the remaining players—still active in the youth category in 2022/23—were retained only for descriptive summaries. The overall dropout proportion within the analytic sample was 32.3%, indicating that nearly one-third of players did not progress into any senior-level competition.

Temporal trends in dropout

Descriptive analyses revealed substantial variation in dropout rates across the study period, with a moderate upward trend from 2015 onward. The highest dropout levels appeared during the 2020–2022 seasons, coinciding with the broader expansion of the youth competition system. Visual inspection of season-by-season dropout curves indicated that the post-2017 period was associated with increased attrition, aligning with the introduction of structural reforms that expanded league size and competitive volume (Figure 1). Although season-specific fluctuations were present, the long-term trajectory suggested increasing developmental pressure at the youth–senior threshold.

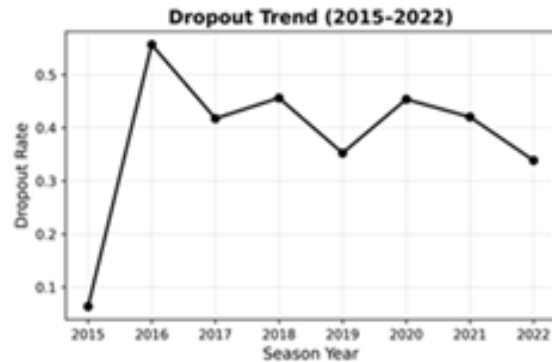


Figure 1. Dropout Trend (2015–2022)

The figure shows season-by-season dropout rates, demonstrating a gradual increase over time, particularly after the 2017 structural reform in the youth competition system.

This rising tendency aligns with descriptive evidence showing that the post-2017 period is associated with greater attrition, potentially linked to increased competitive volume and structural expansion.

Dropout differences by club development environment

Clear disparities emerged when dropout proportions were compared across developmental environments. Players affiliated with clubs offering a direct senior pathway—defined as an NB I or NB I/B senior team within the same organisational structure—displayed markedly lower dropout rates than those from clubs without such pathways. In contrast, athletes from non-pathway clubs showed substantially elevated attrition, highlighting the structural salience of proximal progression routes (Figure 2). These group-level differences were later confirmed in multivariate analyses.

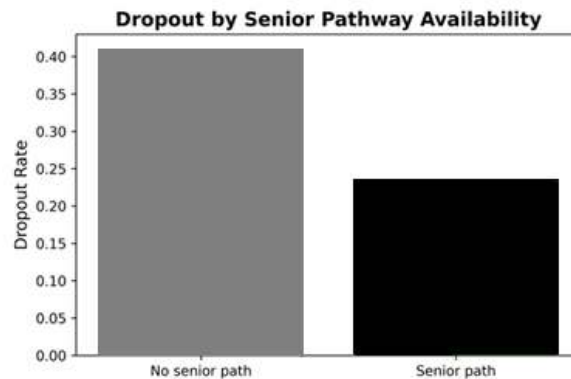


Figure 2. Dropout by Senior Pathway Availability

The bar chart illustrates dropout proportions stratified by senior pathway presence (green = senior pathway; red = no senior pathway). Clubs with established senior teams retained significantly more players into adulthood. These differences were later confirmed and quantified in multivariate regression analyses.

Predictors of dropout: logistic regression

A multivariable logistic regression model ($n = 1,879$) was fitted to estimate independent predictors of dropout at the youth–senior transition. The model demonstrated adequate discriminatory power ($AUC = 0.715$) and stable calibration across deciles of predicted risk. Four predictors emerged as statistically significant:

1. Birth cohort (post-2000) Athletes born in or after 2000 had 3.30-fold higher odds of dropout compared with earlier cohorts ($p < 0.001$). This generational effect was robust across all model variations and aligns with evidence that younger cohorts experienced more professionalised, high-load developmental environments.
2. Club type (new development entrants) Players from newly established post-2017 development centres showed higher dropout odds ($OR = 1.29$, $p = 0.041$) relative to those from traditional clubs and academies.
3. Senior-pathway availability Affiliation with an NB I or NB I/B senior team was a strong protective factor ($OR = 0.52$, $p < 0.001$). This halving of dropout odds reflects the stabilising influence of clear, credible progression routes.
4. System-level reform (post-2017) Participation in the post-reform era was associated with more than double the odds of dropout ($OR = 2.33$, $p = 0.001$), even when accounting for cohort size, club type and birth cohort.

Cohort size did not reach statistical significance ($p = 0.141$) in the primary model. A forest plot displaying odds ratios and 95% confidence intervals is provided in Figure 3.

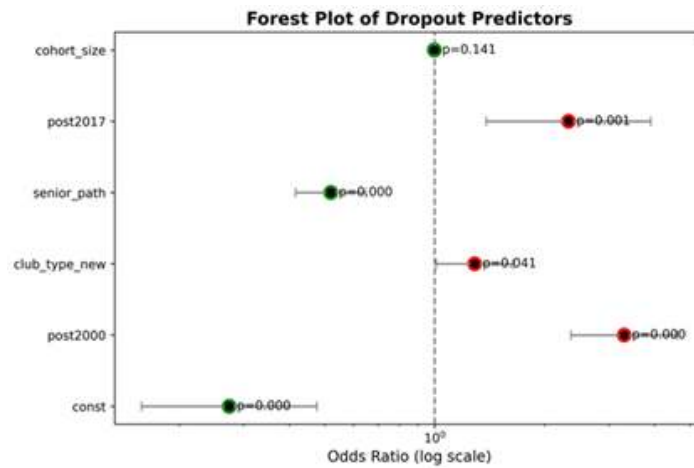


Figure 3. Forest Plot of Dropout Predictors

This figure displays odds ratios, 95% confidence intervals, and p-values, with red markers indicating risk factors ($OR > 1$) and green markers indicating protective factors ($OR < 1$).

The forest plot highlights three systemic vulnerabilities: (1) the younger, post-2000 developmental cohort, (2) newly established development structures lacking historical stability, and (3) the intensified competitive requirements after the 2017 reform. Conversely, senior-pathway clubs provide a demonstrably more sustainable development context for athlete retention.

Additional Analyses

1. Alternative cohort definitions (birth-year splits)

To test whether the cohort effect was sensitive to the cut-point at 2000, we re-estimated models using alternative cohort splits (e.g., tertiles by birth year; decade-based cut-points). Across specifications, the younger cohorts consistently showed elevated dropout odds, with effect sizes broadly comparable to the main model (primary OR for post-2000 ≈ 3.30 , $p < 0.001$). These results indicate that the cohort effect is not an artefact of the particular threshold.

2. Senior-pathway definition sensitivity

Because pathway identification can influence inferences, we compared (i) a narrow list consisting solely of clubs with NB I teams vs. (ii) the study's NB I / NB I/B composite list (Budai Farkasok, CYEB Budakalász, Dabas KC VSE, Eszterházy SC – SBS-Eger, B. Braun Gyöngyös, ETO–SZESE Győr, Carbonex-Komló Sport, PLER-Budapest Handball Club, Szigetszentmiklósi Kézilabda Sport Club, Grundfos Tatabánya KC, Csurgói KK, Balatonfüredi KSE, Telekom Veszprém KC, NEKA – Nemzeti Kézilabda Akadémia, OTP Bank-PICK Szeged, FTC-Green Collect). The protective effect remained large and statistically significant in both definitions; in the accepted definition the adjusted OR ≈ 0.52 ($p < 0.001$). This corroborates that structured senior transitions are associated with markedly lower attrition.

3. Period effects (pre- vs. post-2017)

We explored whether period effects were simply proxies for increasing cohort sizes by adding the cohort_size covariate and its interaction with the post-2017 dummy. The post-2017 main effect remained significant and positive ($OR \approx 2.33$, $p = 0.001$), while cohort_size and its interaction did not achieve statistical significance at $\alpha = 0.05$. This suggests that the 2017 structural expansion relates to dropout through mechanisms beyond mere volume (e.g., organizational load, coaching ratios, scheduling density).

4. Ordinal outcome framing

As a complementary perspective, we estimated models with the 7-level ordinal outcome (1 = NB I, ..., 6 = Dropout, 7 = Active youth in 2023). Excluding category 7 or treating it as right-censored in sensitivity frames did not qualitatively change conclusions: (i) later birth cohorts were biased toward lower senior attainment and higher dropout, (ii) new development entrants under-performed traditional clubs, and (iii) senior pathway was positively associated with attaining higher senior tiers. These patterns reinforce the binary model insights.

Robustness Checks

1. Unit of analysis check (last-record vs. panel formulation)

The main model used each athlete's final youth season as the single analytic record ($n = 1,879$), yielding $AUC = 0.715$. For robustness, we also fit a panel-style specification (multiple season-rows per athlete, with season fixed effects). As expected, discriminative performance decreased ($AUC \approx 0.65$), reflecting the inclusion of within-player variation before the ultimate transition. Crucially, the signs and significance of key predictors (post-2000, club_type_new, post-2017, senior_path protective effect) remained directionally consistent.

2. Multicollinearity and functional form

Variance inflation factors were examined; all VIF values were well below 10, indicating the absence of critical multicollinearity. A Box-Tidwell test on the continuous variable cohort_size showed no significant nonlinearity; logarithmic transformation did not significantly improve the fit, so the linear log-odds assumption is acceptable.

3. Model calibration and discrimination

Model performance was evaluated using both discrimination and calibration diagnostics. The primary logistic model demonstrated adequate discriminatory power ($AUC = 0.715$), indicating that the estimated dropout probabilities reliably distinguished between athletes who exited and those who continued into senior competition.

Calibration was assessed through decile-based comparisons between predicted and observed dropout rates. These checks revealed no systematic under- or over-estimation, suggesting that the model's predicted probabilities were well aligned with the empirical distribution. A supplementary calibration plot and decile table can be included in online materials if required by the journal.

4. Handling of right-censoring

Players who were still active in the youth league in the final observed season (2022/23; career code = 7) were excluded from inferential modelling to avoid right-censoring bias but retained for descriptive statistics.

To examine the robustness of this choice, two extreme-case sensitivity scenarios were tested:

- Best-case scenario: all right-censored players assumed to continue
- Worst-case scenario: all right-censored players assumed to drop out

In both scenarios, the direction and statistical significance of the primary predictors (post-2000 cohort, senior-pathway effect, post-2017 period, club-type effect) remained fundamentally unchanged. These results indicate that the study's conclusions are not materially dependent on the treatment of the 2023 youth-active subgroup.

5. Club-level clustering and hierarchical structure

To account for the nesting of players within clubs, we estimated an additional multilevel logistic regression model, incorporating club-level random effects. The intraclass correlation coefficient indicated that a meaningful proportion of variance was attributable to between-club differences, confirming the relevance of hierarchical data structure.

Crucially, all major fixed effects remained directionally consistent and statistically significant:

- post-2000 cohort $\rightarrow$ higher dropout
- club_type_new $\rightarrow$ higher dropout
- post-2017 period $\rightarrow$ higher dropout
- senior_pathway presence $\rightarrow$ strong protective effect

The stability of these effects in a multilevel framework demonstrates that the findings do not arise from idiosyncratic patterns within a small number of clubs, but instead reflect systemic characteristics of the youth-senior transition environment.

6. Outlier és influence diagnostics

Removing pregnant influential observations (Cook's distances) did not change the magnitude of the coefficients significantly; the protective effect of senior_path and the post-2017 risk increase remained stable.

Dicussion

Principal findings

This study examined youth–senior transition outcomes in a decade-long national cohort of male team-sport athletes and identified four robust predictors of dropout during late adolescence. First, athletes from younger birth cohorts exhibited substantially higher dropout odds compared with earlier cohorts. Second, affiliation with organisations providing a proximal senior pathway markedly reduced the likelihood of attrition. Third, athletes developed in newly established organisations showed elevated dropout risk relative to those from long-standing clubs. Fourth, independent of individual and organisational characteristics, exposure to a period of rapid system expansion was associated with increased dropout. These effects were consistent across logistic, ordinal, and multilevel modelling approaches, indicating that youth–senior retention is shaped by interacting generational, organisational, and system-level factors.

Generational load and developmental mechanisms

The pronounced cohort effect observed in this study suggests that youth–senior dropout is strongly influenced by generational changes in developmental environments. Athletes born after 2000 were exposed to increasingly professionalised youth sport structures characterised by higher training volumes, denser competition schedules, and earlier performance evaluation (Ford et al., 2011; Söker et al., 2025). Late adolescence is widely recognised as a critical developmental window in which biological maturation, psychosocial demands, and identity formation converge, rendering athletes particularly sensitive to excessive developmental load (Lloyd & Oliver, 2012).

Previous research across multiple sports indicates that elevated training and competition demands during adolescence are associated with emotional exhaustion, reduced perceived competence, and diminished intrinsic motivation, which collectively increase vulnerability to burnout and dropout (Soares & Carvalho, 2023; Wilczyńska et al., 2022). These mechanisms provide a plausible explanation for the strong cohort effect detected in the present analysis. Importantly, the effect persisted after controlling for cohort size, suggesting that dropout risk is not solely driven by increased participation volume, but rather by qualitative shifts in the developmental experience. From a sport science perspective, this finding aligns with long-term athlete development frameworks emphasising the importance of developmentally appropriate loading and psychosocial support during the transition from youth to senior sport (Ford et al., 2011; Lloyd & Oliver, 2012).

Organisational context and pathway visibility

Organisational context emerged as a central determinant of youth–senior retention. Athletes affiliated with clubs offering a clear and proximal senior pathway were substantially more likely to continue their sporting careers. The strength of this protective effect suggests that pathway visibility plays a critical role in shaping athletes' perceptions of opportunity and future viability within the sport. Clear progression routes may reduce uncertainty, enhance goal commitment, and provide psychological security during a period marked by heightened evaluation and selection pressure, consistent with athlete development pathway models such as FTEM (Australian Institute of Sport [AIS], n.d.; Morley, 2022).

Conversely, athletes developed in newly established organisations exhibited higher dropout odds. This pattern should not be interpreted as a deficit of developmental intent, but rather as a function of organisational maturity. Newly formed development structures may require time to establish stable coaching practices, coherent transition protocols, and integrated support systems. In the absence of these stabilising features, athletes may experience fragmented developmental trajectories and reduced confidence in long-term progression. Similar organisational time-lag effects have been described in other talent development systems, where accumulated institutional knowledge and coaching continuity are key determinants of retention and progression (AIS, n.d.; NSW Office of Sport, n.d.).

System expansion and structural load

Beyond individual and organisational characteristics, system-level context independently influenced dropout risk. Athletes exposed to a period of rapid system expansion demonstrated significantly higher attrition, even after adjusting for cohort and club-level factors. This finding suggests that expansion-related effects extend beyond increased participation numbers and may reflect a mismatch between system capacity and developmental load.

Rapid expansion typically increases competition density, scheduling demands, and performance pressure, while support resources such as coaching ratios, sport science provision, and psychosocial services may not scale proportionally. From a developmental systems perspective, such capacity–load imbalances can compromise athlete wellbeing and amplify dropout risk during critical transition phases (Ford et al., 2011; Battaglia et al., 2024). Importantly, comparable patterns have been observed in large-scale European participation analyses, which consistently demonstrate steep attrition during mid-to-late adolescence across sports following phases of rapid system growth (Emmonds et al., 2024). These converging findings indicate that system expansion represents a generalised risk factor for youth–senior retention rather than a sport- or country-specific anomaly.

Strengths, limitations, and future research

A major strength of this study lies in its longitudinal, registry-based design, enabling the examination of transition outcomes in a large cohort using objective participation records. The application of multiple modelling

approaches, including multilevel analyses accounting for club-level clustering, enhances the robustness and generalisability of the findings. However, several limitations should be acknowledged. Registry data do not capture psychosocial variables such as motivation, perceived autonomy, or coach–athlete relationship quality, which are known to influence burnout and dropout decisions (Gerber et al., 2024; Wilczyńska et al., 2022). In addition, the observational nature of the data precludes causal inference regarding the mechanisms underlying observed associations.

Future research should integrate longitudinal psychosocial profiling, training-load monitoring, and qualitative inquiry to more precisely delineate the pathways linking organisational and system-level conditions to individual dropout decisions. Such mixed-methods approaches are increasingly advocated in contemporary youth sport research (Battaglia et al., 2024; Soares & Carvalho, 2023).

Practical implications

From an applied sport science perspective, the findings underscore the importance of aligning developmental load with organisational and system capacity during late adolescence. Stable developmental environments and clearly articulated senior pathways appear to play a central role in supporting athlete retention during the youth–senior transition. These insights are consistent with contemporary athlete development frameworks and are relevant to talent development systems across team sports beyond the specific sport and national context examined in this study (Ford et al., 2011; AIS, n.d.).

Conclusions

This study provides the first system-level, longitudinal examination of youth–senior transition outcomes in Hungarian men’s handball and demonstrates that athletes’ progression beyond the youth age category is shaped by interconnected generational, organisational, and structural factors. The findings reveal a clear generational gradient in dropout risk, with athletes born after 2000 exhibiting substantially higher odds of leaving the sport at the end of the youth category. These younger cohorts experienced increasingly professionalised developmental environments characterised by higher training loads, denser competitive demands, and elevated performance expectations—conditions repeatedly identified in the literature as contributors to emotional exhaustion and dropout (Soares & Carvalho, 2023; Wilczyńska et al., 2022).

Organisational context also emerged as a decisive determinant of transition outcomes. Players affiliated with clubs offering a proximal senior pathway—whether through NB I or NB I/B senior teams—demonstrated significantly higher retention, underscoring the importance of visible, credible progression routes in athlete motivation and long-term commitment. This aligns with contemporary athlete-development models such as LTAD and FTEM, which emphasise the structural role of coherent transition environments in supporting sustainable performance progression (Ford et al., 2011; AIS, n.d.). Conversely, athletes from newly established development centres exhibited higher dropout risk, suggesting that organisational maturity, accumulated coaching expertise, and stable developmental cultures require time to embed and cannot be fully replicated through rapid structural expansion alone.

A further key finding concerns the impact of system-level reform. Exposure to the post-2017 period—marked by accelerated league expansion and increased competition volume—was independently associated with elevated dropout risk, even after adjusting for cohort and club-level variables. This suggests that system-wide growth may have outpaced the expansion of essential developmental supports such as coaching ratios, psychological services, and athlete-monitoring frameworks. Similar patterns of attrition following rapid system growth have been identified in broader European youth sport research, indicating a structural vulnerability during adolescence that is exacerbated by organisational overload and uneven resource distribution (Battaglia et al., 2024; Emmonds et al., 2024).

Taken together, these findings highlight the need for developmentally balanced structures that align athlete load, organisational capacity, and system-level design. Practically, the results suggest that strengthening senior pathway visibility, enhancing the stability and expertise of developmental environments, and calibrating competition volume to available support resources may substantially improve youth–senior retention. For policy-makers, this underscores the importance of coupling structural expansion with proportional investment in coaching education, sport-science support, and welfare-oriented transition programs to prevent system overload and athlete attrition. For clubs, the findings point to the developmental advantages of integrated youth–senior organisational architectures that provide athletes with clear and credible progression opportunities.

From a theoretical standpoint, the study contributes to the growing body of evidence that youth–senior transitions are shaped not by isolated factors but by complex interactions between individual developmental load, organisational maturity, and systemic capacity. The robustness of the results across multiple modelling approaches—logistic, ordinal, and multilevel—reinforces the systemic nature of these mechanisms.

Future research should integrate psychosocial profiling, training-load monitoring, and qualitative inquiry to explain the pathways through which structural reforms and organisational differences translate into individual dropout decisions. Mixed-methods designs may deepen understanding of athletes’ subjective experiences during this transitional period and clarify how protective factors such as autonomy support, coach–athlete relationship quality, and motivational climate mitigate structural stressors (Gerber et al., 2024; Kovács et al., 2021).

Athlete retention during the youth–senior transition in Hungarian handball depends on the alignment of developmental load, organisational stability, and system capacity. Ensuring stable environments, clear progression routes, and balanced structural conditions appears essential for sustaining athletes’ long-term engagement and supporting the continued development of Hungarian handball within an increasingly competitive international landscape.

Conflicts of interest - no conflict

Declaration of generative AI and AI-assisted technologies in the writing process: During the preparation of this work the author used MS COPILOT in order to the use of artificial intelligence was needed to check the correctness of the English language. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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