Clustering and tracking performance trajectories in children: a longitudinal study of physical fitness and motor skills

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Résumé

Introduction: Physical fitness and motor skills are key components of children's health and development, with strong evidence linking higher fitness levels to better cardiometabolic health, mental well-being, and long-term physical activity. Early childhood is a critical period for developing these capacities, laying the foundation for lifelong habits (Ortega et al., 2008). Multisport programs with diverse motor tasks support overall development. However, children differ in baseline fitness and developmental trajectories, influenced by age, growth, and maturation (Malina, 2014). These differences can lead to heterogeneous responses, often masked by traditional group-level analyses. Identifying distinct performance profiles and tracking their evolution is therefore essential. Cluster analysis provides a robust approach to classify children into meaningful subgroups and track their dynamic responses (Blyth et al., 2025). This study aimed to identify and characterize physical performance profiles in children participating in a weekly multisport program and track their evolution over one academic year.
Methods: This longitudinal study included 205 children aged 6 to 11 years who participated in a multisport program over one academic year (1.5 hours/week). The intervention aimed to enhance physical fitness and motor skills through diverse activities. Assessments were conducted at the beginning (S1) and end (S2) of the school year using standardized tests: maximal handgrip strength, 30-meter sprint, countermovement jump, and the Test of Gross Motor Development (TGMD-2). Anthropometric data (age, height, body mass index (BMI)) and biological maturation markers (peak height velocity (PHV), maturity offset) were also collected.

Wilcoxon signed-rank tests assessed within-subject changes between S1 and S2. Principal component analyses were conducted at each time point to reduce dimensionality and summarize overall performance. Based on extracted components, K-means clustering was then applied to identify distinct performance clusters. Cluster-specific comparisons of age, height, BMI, PHV, and maturity offset were performed using ANOVAs and Kruskal–Wallis tests. Transitions between clusters from S1 to S2 were then analyzed to evaluate changes over time and their association with age and maturation.

Results: Significant improvements were observed across all performance measures between

*Intervenant

S1 and S2 (all $p < 0.001$). At both time points, cluster analysis identified three groups-Low, Medium, and High-representing ascending levels of physical fitness and motor skills.

Over the year, 61.9% of participants remained in the same cluster. Among the 37 children initially in Low, 28 (75.7%) moved to Medium, 3 (8.1%) to High, and 6 (16.2%) remained Low. Of the 133 in Medium, 105 (78.9%) remained, 22 (16.5%) moved to High, and 6 (4.5%) dropped to Low. Among the 35 initially in High, 16 (45.7%) remained, while 19 (54.3%) transitioned to Medium. Children in the Low group had the highest progression rate (83.8%), while those in High showed the highest decline rate (54.3%).

Significant differences in age, height, and maturation were observed between several transition groups. Notably, children who remained in High were older (8.62 years), taller (138.6 cm), and more biologically mature (PHV: 12.91 years), while those remaining in Low were the youngest (6.31 years), shortest (119.0 cm), and least mature (PHV: 11.68 years). BMI did not differ significantly across groups.

Conclusion: This study highlights the heterogeneous responses of children to a multisport intervention. While most participants maintained a stable profile, many initially low-performing children improved, resulting in few remaining in the Low cluster. Conversely, over half of the High performers moved to Medium, suggesting a possible ceiling effect. Such programs may benefit children with lower initial performance but appear less effective in supporting progress among higher-level children. Clustering approaches offer valuable insights into individual trajectories and may help guide adaptive interventions.

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