

Exploring the Relationship Between Anthropometric Characteristics and Physical Performance in Football Players

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Abstract: Physical and mental health represents one of the main concerns of nowadays society, characterized by sedentarism, unhealthy food and unprecedented multimedia impact. Under these circumstances, sports are a sustainable alternative to overcome nowadays society's challenges, with social, economic and personal positive effects. Thus, the purpose of this study was to identify the relationships between the anthropometric and physical indicators, measures between 2022 and 2025, of the University of Oradea FC football team's players. The research methodology used was multicriterial analysis. In this respect, 9 indicators were analyzed, 4 anthropometric and 5 physical ones. The results showed the existence of strong negative relationships, followed by positive strong relationships, negative weak and positive weak relationships. The preponderance of strong negative relationships indicated the role of sports in children's harmonious and balanced development. Based on tendencies in the evolution of relationship types according to the differences between the values of -1 and 1, assumptions were made and some players were identified in need of personalized training programs, as well as players for whom it was necessary to depict external factors to make the training more efficient and to improve their athletic performance.

Keywords: anthropometric indicators, physical performance, football players, youth athlete development, training optimization

Introduction

Oradea is one of the large cities of Romania, being currently characterized by a process of accelerated spatial expansion in favor of cars and to the detriment of people, especially children. Given that physical activity is essential to a healthy and balanced society, the need for movement and sports represents an alternative to

combat sedentarism and to provide children with a pleasant, dynamic form of leisure, with medical, emotional, and intellectual benefits (Papp et al., 2019; Erdely et al., 2020; Ilieș & Caciora, 2020). This can be achieved through sports clubs, which, in addition to identifying and selecting future talent, also support athletic performance. The motivation for moving and practicing sports depends on a series of factors such as children's psychosocial status, their physical and physiological characteristics, type of sport, available time, costs, existence of specialized units and organizations, economic, social and political context.

Some children registered in clubs will attain a certain level of athletic performance. This can be also influenced by a series of factors, including physical and physiological features, level of motivation and psychosocial status (Koç et al., 2020; Podstawski et al., 2020; Podstawski & Marzec, 2021; Stanković et al., 2023). Bulz et al. (2024) concludes that the exposure to innovative activities during physical education and sports classes significantly increases children's inclination towards active participation and sustained exercise behavior. The way and share in which these factors are associated in establishing the athletic trajectory differs from one athlete to another, reason why a complex approach is required. There were instances in which coaches focused primarily and for an extended period on improving athletes' physical condition, without assessing their body composition (Popovic et al., 2014). Understanding physical and physiological characteristics is essential for enhancing athletes' performance, identifying talent, determining player positions, and designing appropriate training methods (Radaković et al., 2025). Șandra et al. (2022) said that physical training should be a primary objective in the development of young athletes, providing a strong foundation for their future athletic performance. The importance of athletes' anthropometric characteristics and motor skills in competition was also noted (Stanković et al., 2023). Thus, the advantages of body composition, height and weight were determined compared to the players' dynamic requirements (sprints, jumps and direction changes) (Popovic et al., 2014; Koç et al., 2020). Considering the same features, other studies have reported differences in athletic performance across various sports (Masanovic et al., 2019; Stankovic et al., 2023). Different exercises with diverse neuromuscular demands foster dynamic stereotypes that engage the body's major systems (Șandra et al., 2023a; Șandra et al., 2023b). Yet, most children registered in football clubs will not achieve remarkable athletic performances for various reasons, including the anthropometric and physical features. Under these circumstances, knowing the relationships between the anthropometric indicators and the physical ones shows how the club manages to guide children towards sports and physical exercises in an organized manner. The children's harmonious development by reaching a balance between the anthropometric indicators and the physical ones ought to be one of the main objectives of sports clubs, having effects on

social, emotional and psychological levels. The introduction of modern training tools and methods into the training process of children in the pubertal stage has a positive impact on their motor and psychomotor development as well (Bulz et al., 2023). Despite the large volume of studies and research, it can be noticed that studies focusing on establishing the relationship types between anthropometric and physical indicators, measured over a specific period, of young children football players, are scarce. In football, physical preparation is a central element of athlete development, underpinning performance outcomes in both training and competitive contexts (Şandra et al., 2023). Therefore, the purpose of the study was to identify and explore the relationships between anthropometric and physical indicators, measured between 2022 and 2025, of players from the Oradea University football team's 2012 generation.

In the literature, numerous studies have assessed the relationships between anthropometric and physical indicators and athletic performance (Bénéfice & Ndiaye, 2005; Staub et al., 2018; Yusni et al., 2025), optimized training (Norton et al., 1996; Brocherie et al., 2014; Althuwaini & Fahad, 2025; Kwon & Kim, 2025), identified talent (Mohamed et al., 2009; Boostani et al., 2011; Hume & Stewart, 2017; Sajjadipour et al., 2025), and established players' positions (Mahmoud et al., 2021; Piqueras et al., 2021; Arslan et al., 2025).

The novelty of the study lies in applying a multicriteria method to assess anthropometric and physical indicators at the level of a children's football team over 4 years (2022-2025). The obtained results may provide essential information regarding the children's balanced development, based on the anthropometric and physical features, the need to introduce personalized training, identification of children with exceptional ability and establishing the trajectory of the future athletes.

The study's research hypotheses dwell on the fact that on the level of the Oradea University FC football team, 2012 generation, there are strong relationships between the anthropometric and physical indicators and, as a result of constant training, in time, the evolution of the relationship indicator is positive, with values approaching 0, being conditioned by the evolution of the physical indicators.

The research questions are as follows: Do anthropometric and physical indicators change after participation in sports training? What kinds of evolutions are there? Are there any relationships between the evolution of the physical, respectively of the anthropometric indicators? What kind of relationships are there?

Materials and methods

The data used in this study were systematically collected annually from medical and functional assessments of the Oradea University FC team's players from the 2012 generation over four consecutive years (2022-2025). The measurements were made

in the month of May of each year, under the club's sports physician's coordination who performs an annual medical specialty check up to grant the yearly endorsement of athletic activity ("Fit for sports/football").

During these examinations, the research team, together with the sports physician, collected and recorded anthropometric and functional data with the informed consent of the children's parents (UE 2016/679 – GDPR Rule). All data were anonymized and used exclusively for scientific and educational purposes.

Table 1. Indicators and variables used

Assessment field	Variable / Test	Used instrument	Technical features / Precision
Anthropometrics	Height (cm)	Vertical stadiometer	Millimetric ruler, perpendicularly fixed; precision ± 0.1 cm
	Body weight (kg)	Digital scale	Pressure sensor; pre-test calibration; precision ± 0.1 kg
	Thoracic elasticity (cm)	Flexible anthropometric centimetre	Nonelastic material; measured in inhaling/exhaling; precision ± 0.1 cm
	Vital pulmonary capacity (ml)	Portable spirometer	According to ATS/ERS standards, selection of the best one out of three attempts
Physical testing	Speed (time at 50 m)	Digital timer; running track of 50 m	Timing at ± 0.01 s; flat, marked surface
	Resistance (distance in 8 minutes)	Digital timer; metric measuring tape	Precise timing; distances marked with precision ± 1 m
	Abdominal strength (sit-ups/30 sec)	Digital timer; gymnastics mattress	Timing ± 0.01 s; manual counting of correct repetitions
	Arms strength (push-ups/30 sec)	Digital timer; gymnastics mattress	Timing ± 0.01 s; standardized visual assessment
	Lower limbs strength (squats/30 sec)	Digital timer; marked testing area	Timing ± 0.01 s; manual counting of correct repetitions

The measurements were made within the club's sports facilities, under standardized temperature and training program conditions, to be able to compare data from different years. The same measurement procedures and instruments were used each time to ensure consistency and validity.

To collect the anthropometric data, standardized instruments were used, in accordance with the recommendations of the World Health Organization and International Institute of Applied Anthropometrics. All instruments were calibrated before measurements and the procedures were made under controlled conditions, respecting the somatic assessment specific methodology norms. Height was determined by using a vertical stadiometer with millimetric ruler, fixed on a rigid plane and perfectly perpendicular on the floor. The subject was positioned in orthostatism, with the heels, shoulder blades, and posterior aspect of the head in contact with the vertical surface, gazing into the Frankfurt plane. The measurement was recorded in centimeters, with a precision of ± 0.1 cm. Body weight was measured with an electronic scale with pressure sensor, calibrated before testing. The subjects

were weighed on wearing light clothing and no shoes. The values were expressed in kilograms, with an accuracy of ± 0.1 kg. Thoracic elasticity (thoracic expansion) was determined with the help of a flexible, nonelastic anthropometric measuring tape. Measurements were taken of the thoracic perimeter during maximal inhalation and maximal exhalation; the difference between the two values represent thoracic elasticity. The instrument allows a precision of ± 0.1 cm. Pulmonary vital capacity was assessed using a portable spirometer in accordance with ATS/ERS (American Thoracic Society/European Respiratory Society) standards. The subjects executed forced exhaling after a maximum inhale and the best out of three consecutive attempts was considered the reference value. The results were expressed in milliliters (Table 1).

The assessment of physical performance was made by means of a series of standardized test, using instruments specific to each test. All measurements were made under controlled conditions, on appropriate surfaces, and in accordance with the methodological protocol established for each motor skill. Speed was assessed over a 50 m distance, marked on a flat, level sports field. The execution time was measured with a digital timer with precision of ± 0.01 s. The start signal was given from a free position and the time was recorded from the moment the running started until the finish line was crossed. Aerobic resistance was assessed by continuous running for 8 minutes on a field marked with the respective distances, measured with a measuring tape. The digital timer was used to comply with the standard time and the distance was determined by reading the fixed marks at the end of the test. The instruments provide a precision of ± 1 m for distance, and ± 0.01 s for time. Abdominal muscle strength was assessed by the number of situps performed in 30 seconds. The exercise was performed on a standard gymnastics mat to ensure the subjects' comfort and safety. The number of correct repetitions was recorded using a digital timer, with a time precision of ± 0.01 s. The strength of upper limbs extension was tested by the number of pushups made in 30 seconds. The subjects made the exercise on a flat surface, using the mattress for comfort. The number of correct repetitions was visually monitored, and timing was performed using a digital timer with a precision of ± 0.01 s. Lowerlimb strength was assessed by the number of squats performed in 30 seconds. The test was carried out on a flat surface, delimited for safety and stability. Time was measured with a digital timer and the correctly made repetitions were manually counted by the examiner (Table 1).

The sports physician played a significant role in coordinating the datagathering process by verifying the accuracy of anthropometric, functional, and physiological measurements. Moreover, they helped interpret the obtained clinical values and completed the athletic skills medical charts, based on which the players received their annual medical endorsement to participate in competitions. By the constant

cooperation between the medical staff and the technical team, a longitudinal database was created, essential for monitoring the athlete children's growth and development, and for early identification of physical imbalances or deficits.

The annual monitoring of these indicators allows for a longitudinal tracking of young athletes' physical and functional development, essential aspect for: identifying the deviations from the standard growth curves; adjusting the training load according to biological age, not only chronological; preventing overexertion and injuries by adjusting effort to the child's real capacity; individualized planning of longterm physical training.

According to Piqueras et al. (2021), the anthropometric and physical assessment made at least once a year represents a minimum standard for the athletic formation academies, contributing to the optimization of young athletes' selection, progress and health. Thus, maintaining a longitudinal database regarding the anthropometric indicators, speed, resistance and strength is crucial for any sports structure which targets young football players' sustainable development.

Based on the gathered data, the variable values of the analyzed indicators were normalized (between 0 and 1) and the aggregate and synthetic values were calculated for the anthropometric and physical indicators. The analysis of players was tracked through the synthetic anthropometric and physical indicators to emphasize the situations and their concrete annual evolutions and over the analyzed period. The last stage of the study was represented by the calculation of the relationship indicator (between anthropometric and physical indicators) (Boc et al., 2022; Deac et al., 2023; Herman et al., 2024a; Herman et al., 2024b; Herman et al., 2025a; Herman et al., 2025b; Arslan et al., 2025) and the analysis of players based on this, emphasizing this way the relationship types between the anthropometric and physical indicators, the role of training and the evolution tendencies on team level and on individual, player level.

Results

Analysis of anthropometric indicators

The assessment of anthropometric and functional indicators represents a fundamental component of monitoring young athletes, being directly correlated with performance potential and injury prevention.

To identify and explore the synthetic anthropometric indicator for each player (18 players), member of the Oradea University FC football team, information was gathered once a year, between 2022-2025, regarding height, body weight, thoracic elasticity and vital pulmonary capacity.

The first measurement of anthropometric indicators for each player showed varied nominal values, thus, for the height indicator, in 2022, at the age of 10, they

were between 132 cm, player 8, and 155 cm, player 3. The nominal difference between the tallest player's height and the shortest player's height was 23 cm in 2022. In 2023, the players were 11 then, the smallest height was measured for player 8, similarly to the previous year, 135 cm, growing 3 cm since then. The maximum height measured was 158 cm, player 3, just as the prior year, growing also 3 cm, so the height difference between minimum and maximum remained of 23 cm. The following year, 2024, player 3 was once again the tallest in the team, 160 cm, with a growth of 2 cm, however, the shortest player that year was not player 8 anymore (143 cm), who grew 8 cm, but player 18 (140 cm), who grew 2 cm in the first year and 3 cm in the 2nd one. The difference between the minimum, maximum values, was 20 cm. The measurements in 2025 showed the same trend regarding maximum and minimum values, thus, player 3 was the tallest (166 cm), a 6 cm growth compared to the previous year, and the shortest player was player 8, 144 cm, with a growth of only 1 cm. The difference between the two values was 22 cm.

As expected, all players grew in height during the studied period, between 1 cm per year (player 7, from 10 to 11 years; player 8 from 12 to 13 years) and 11 cm per year (player 7 from 11 to 12 years). During the entire period, player 16 recorded a growth of only 7 cm, 2 cm in the first year, 3 cm in the second and 2 cm in the third, while player 12 recorded a growth of 24 cm in total, being noticeable a constant, yet significant growth from year to year of 8, 9, respectively 7 cm.

Players' body weight in 2022, at age 10, ranged from 25 kg (player 18) to 39 kg (player 14), with a 14 kg difference between the two values. The following year, the minimum weight was 28 kg, player 15, while the maximum weight was 44 kg, player 14. In 2024, player 18 had again the smallest weight, 30 kg, and player 14, the most significant weight, 48 kg. The following year, players 18 and 2 had the smallest weight, 39 kg, and the maximum value, of 55 kg, was recorded for player 1 and player 12.

Analyzing the evolution of body weight nominal values, none of the players lost weight, the growth rhythm, however, being different from player to player and from one measurement to the next one. From the 2022 measurement, when the players were 10 years old, to the 2023 measurement, 11 years old, players 2, 4, 6, and 15 gained the least weight, 2 kg each, while player 17 gained the most weight, 7 kg. The other players gained between 3 and 6 kg. In 2024, player 18 was 1 kg heavier than the previous year, recording the smallest gain over that year, while players 10, 12 and 13 gained 8 kg each. The maximum gain weight in 2025 was recorded for player 1, who gained 15 kg and the minimum value of weight gain was 2 kg, player 2. The other players gained between 4 and 9 kg. It can be noticed the maximum growth value of 15 kg as being significant and unique within the football team.

At the age of 10 (2022), the football players' thoracic elasticity ranged from 4 cm (players 9 and 16) to 9 cm (players 7, 8, and 18). The following year, 2023, the

minimum value was also 4 cm, but the number of players with this value increased (players 2, 3, 5, 12 and 14). The maximum thoracic elasticity value was 10 cm for players 7, 8 and 10. The minimum and maximum values, of 4 cm, respectively 10 cm, were maintained in 2024 as well, player 4 recording the minimum value and player 9, the maximum value. In the subsequent measurement, 3 players recorded the minimum value of 5 cm (players 5, 6, and 7), and 1 player recorded the maximum value of 10 cm (player 11).

Although the minimum and maximum values recorded over the studied period were similar or with a difference of 1 cm, the thoracic elasticity evolution during the 4 years was oscillating, with increases and decreases of nominal values in case of each player from one year to the next one.

The vital pulmonary capacity measured at age 10 (in 2022) had a minimum of 900 ml for players 11 and 12 and a maximum of 1900 ml for player 4. In 2023, the vital pulmonary capacity increased in the case of most players, the minimum value was 1100 ml, player 11, and the maximum value was of 2400 ml, player 1. The measured values in 2024 ranged from 1200 ml (player 11) to 2700 ml (player 1). At the final measurement, in 2025 (at the age of 13), the minimum vital pulmonary capacity value was 1800 ml, players 2, 7, 10, 15 and 16, and the maximum value was 2900, player 1.

The vital pulmonary capacity evolved in a consistent upward trend from one measurement to the next. For each player, the highest increase was recorded at the measurements in 2024 and 2025, of 800 ml, for player 11 who, in 2022, had the minimum value for that year, of 900 ml, 1200 ml in 2024 and reaching 2000 ml in 2025.

The anthropometric indicators of height, body weight and vital pulmonary capacity showed increase in value from one measurement to another and for each player. The only anthropometric indicator which oscillated from year to year either increased or decreased, without following a certain ascendent or descendent trend, was the thoracic elasticity indicator.

Based on the nominal values of the assessed anthropometric indicators, the synthetic values of these indicators were calculated for each football player, for each year when they were evaluated (Figure 1).

In 2022, for 13 of 18 football players, the synthetic values were between 0 and 0.5, with the nominal values of these indicators ranging from the minimum toward the average. The other 5 players had synthetic values between 0.51 and 1, with nominal values for their anthropometric indicators near the maximum. The synthetic value closest to 0 was that of player 15 (0.1146), with nominal values for his anthropometric indicators at the upper end of the range, or even at maximum values. The synthetic values of the anthropometric indicators obtained for 2023 (age 11)

place 12 players within the 0 and 0.5 range. In the case of those with a smaller synthetic value (closer to 0) by comparison to the previous year, for example, players 2, 15, 18, the nominal values of their anthropometric indicators increased, yet were still in the lower part of the range in 2023 as well. The other 6 players had synthetic values between 0.51 and 0.75, with no player exceeding 0.75. In 2024, the situation was similar to that in 2023, 10 players had synthetic values between 0 and 0.5 and the values of 8 players were between 0.51 and 1. It can be noticed the overpassing of the 0.5 threshold by players 1, 12 and 13, whose indicators had nominal values in the lower part of the range for 2023, values which increased significantly by the 2024 measurements. In 2025, there were also 10 players with synthetic values between 0 and 0.5, and 8 players with values between 0.51 and 1. The value of player 9 decreased under 0.5 and the value of player 11 increased by over 0.51. No player had a synthetic value higher than 0.75. Out of the total of 18 players, 8 of them had a synthetic value between 0 and 0.5, and the nominal values of their anthropometric indicators were in the lower part of the range in all measurements from all 4 years. Player 7 stands out with a low synthetic value (0.0994), between 0 and 0.25, with nominal values that increase by a constant yet small amount across all 4 measurements.

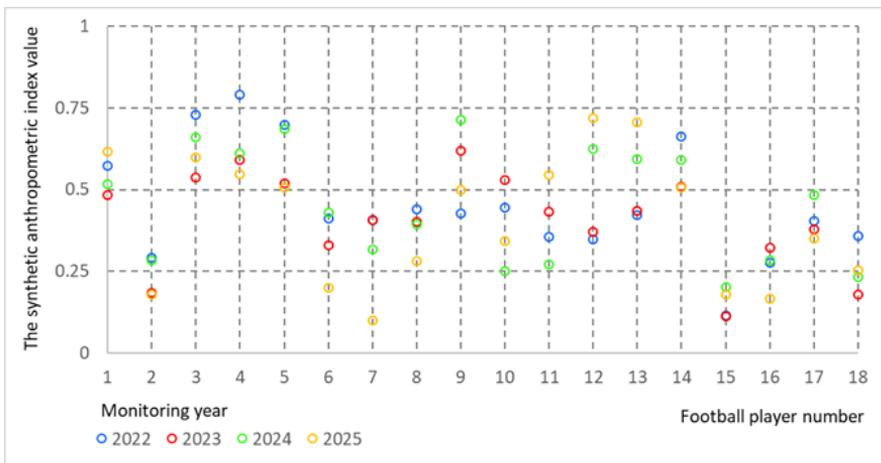


Figure 1. Distribution of synthetic values of the anthropometric indicators for each player

Analysis of physical indicators

Tourism To identify and explore the synthetic physical indicator, information was used regarding speed, resistance, abdominal strength, upper and lower limbs strength of the target group (Figure 2).

Football is a very dynamic sport and the speed of players (time achieved at 50 m sprint) is very important for the efficacy of the players’ training, as well as for their performance during the game. The players’ speed measurements at age 10 (in 2022)

ranged from 9.98 s/50 m (player 12) to 11.3 s/50 m (player 3). At the second measurement, it was noticed an increase of speed for all players, except player 12, in his case, speed decreased from 9.98 s/50 (the lowest in 2022) to 10.13 s/50 in 2023. For the 11-year-old players, speed ranged from 9.59 s/50 to 10.54 s/50. The increasing trend was maintained in 2024 as well, with values ranging from 8.96 s/50 (player 4) to 10.25 s/50 (player 7). In the case of 2 players, decreases in speed were observed: player 11 from 9.68 s/50 in 2023 to 9.83 s/50 in 2024, and player 17 from 9.86 s/50 in 2023 to 9.83 s/50 in 2024. All the other players were characterized by increase in speed. At the 2025 measurements, 3 of the players showed decrease of speed value: player 7, from 9.1 s/50 in 2024, to 9.25 s/50 in 2025; player 9, from 9.08 s/50 in 2024, to 9.18 s/50 in 2025, and player 14, from 8.97 s/50 in 2024, to 9.23 s/50 in 2025. The other players' speed increased in 2025, by comparison with 2024. The maximum speed recorded in 2025 was 8.37 s/50, player 10, while the minimum was 9.58 s/50, player 6.

The football players' resistance was assessed by measuring the distance they covered over 8 minutes. The first measurement, taken in 2022 (at age 10), yielded values ranging from 1,002 m/8' (player 13) to 1,380 m/8' (player 10). In 2023, the nominal values were between 1,211 m/8' (player 9) and 1,485 m/8' (player 18). The tendency was of increase, except 4 players, in cases of whom resistance decreased in 2023 by comparison with 2022: player 9 (from 1,211 m/8' in 2022 to 1,101 m/8' in 2023); player 11 (from 1,380 m/8' to 1,249 m/8'); player 12 (from 1,280 m/8' to 1,247 m/8'). The nominal resistance values for 2024 were between 1,239 m/8' and 1,510 m/8'. Six of the players showed tendencies of resistance decrease while the other 12, of increase. The most important decrease was in player 18's case, from 1,485 m/8' in 2023, to 1,302 m/8' in 2024. The value range for 2025 was between 1,377 m/8' and 1,615 m/8', the general tendency being of increase by comparison with the previous year, except 4 players: player 3 (from 1,430 m/8' to 1,424 m/8'); player 4 (from 1,510 m/8' to 1,490 m/8'); player 13 (from 1,478 m/8' to 1,385 m/8') and player 15 (from 1,434 m/8' to 1,405 m/8'). Resistance increased from the first measurement (2022) to the last one (2025) for all players, even though from one year to the other, decreases in resistance were recorded in some players' cases.

To assess players' abdominal strength, it was considered the number of sit-ups accomplished within 30 seconds. In 2022, the minimum number of sit-ups made in 30 seconds was 13 (4 players), while the maximum was 16 (4 players). In 2023, the minimum number was 15/30/sec (1 player) and the maximum, 20/30/sec (3 players). All players managed to accomplish a higher number of sit-ups, compared to the previous year. The following year, 4 players accomplished 19 sit-ups/30/sec, the minimum number that year, and other 4 players made 23 sit-ups/30/sec the maximum number for 2024. This year, all players increased the number of sit-ups

performed in 30 seconds compared with the previous year. In 2025, the minimum number of sit-ups/30/secs was 22 (3 players), while the maximum was 27 (player 18). The evolution of sit-up number accomplished in 30 seconds was ascendant, both from 2024 till 2025 and from the beginning of the assessment period until its end.

To assess the upper limbs' strength, the players made push-ups and it was considered the number of push-ups made in 30 seconds. In 2022, the minimum number of push-ups made in 30 seconds was 5 (player 3) and the maximum number was 10 (players 10, 11 and 14). The following year, the minimum number was 8 push-up/30/sec (players 3, 6 and 13), and the maximum was 13 (player 5). Except 3 players, the others managed to accomplish a higher number of push-ups/30/secs compared to the previous year. Those 3 made an equal number of push-ups with those made the year before: player 3 – 8 push-ups; player 13 – 8 push-ups and player 14 – 10 push-ups. In 2024, the minimum number of push-ups made in 30" increased to 11 (players 1 and 7), and the maximum number increased to 15 (players 10, 16 and 17). All players performed more push-ups than in the previous year. At the final measurement (2025), the minimum number of push-ups was 13 (player 1) and the maximum was of 17 (players 4, 11, 15 and 17). It can be noticed that in 2025, there were more players (4) who accomplished the maximum number of push-ups. All players made a higher number of push-ups in 30", compared to 2024.

The squat was the exercise with which the strength of lower limbs was assessed, more specifically, the number of squats made in 30 seconds. Thus, the minimum and maximum values for 2022 were 17 (player 1), respectively 22 (player 14). In 2023, the minimum number of squats/30/secs was 20 (player 3), while the maximum was 26 (player 17). The evolution of accomplished squats number, and implicitly of lower limbs' strength, was ascendent for all players. In 2024, the minimum number of squats accomplished was 25/30/secs (player 3), and the maximum number was 31 (players 11 and 17). The evolution of lower limbs' strength was also ascendent in the cases of all players. In 2025, a minimum number of 28 squats/30/secs were made (player 13) and a maximum of 34 (player 16). The ascendent trend was maintained.

After measuring the nominal values of the football players' physical indicators over the study period, the synthetic values of these indicators were calculated for each player at each measurement (Figure 2). Thus, in 2022, 10 players had synthetic values between 0 and 0.5, and 8 had values between 0.51 and 1. The best placed player in 2022, from synthetic value viewpoint, was player 1 (0.1763), whose nominal values for the physical indicators were in the middle section of the range. The player with the synthetic value farthest from 0 was player 14 (0.8632), whose nominal values were near the maximum of the range. In 2023, 8 players had synthetic values for their physical indicators between 0 and 0.5, whereas the other 10 had values between 0.51 and 1. The player with the lowest synthetic value was player 3 (0.2344), with average-

to-small nominal values, and the player with the highest synthetic value was player 10 (0.8519), whose nominal values were medium-to-high. In 2024 (at the age of 12), for 7 players, the synthetic values were between 0 and 0.5, respectively for 11, the values were between 0.51 and 1. Player 1 was, once again, the player with the lowest synthetic value (0.1962), with nominal average, towards small, nominal values. The player whose synthetic value was farthest from 0 was player 17 (0.8229), with nominal values close to the maximum, or even at the maximum, for some physical indicators. In 2025, 5 players had synthetic values between 0 and 0.5, while all the other players had synthetic values between 0.51 and 1. Player 1 remained the player with the synthetic value closest to 0 in 2025 (0.0694), with average-to-minimum nominal values for his physical indicators. The highest synthetic value was player 17 (0.849). Players 1, 3, 12, and 13 had synthetic values between 0 and 0.5 throughout the study period, whereas players 5, 10, 11, and 14 had synthetic values between 0.51 and 1 at all measurements (Figure 2).

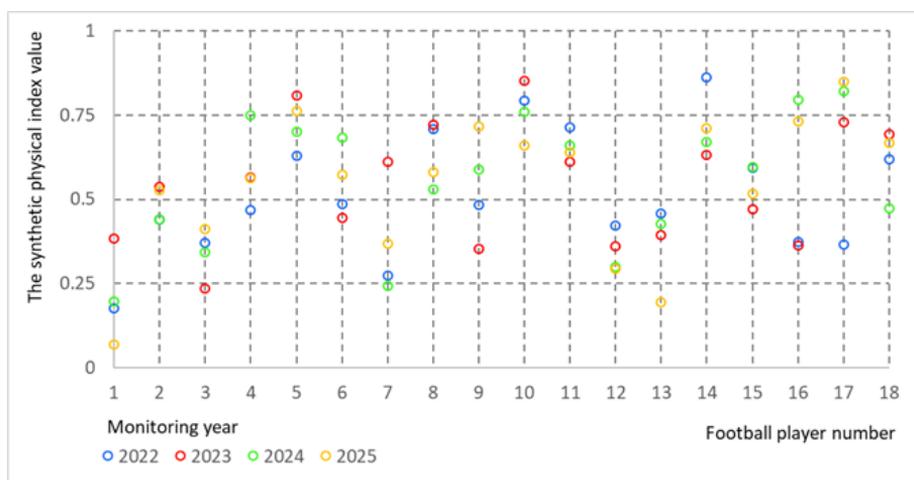


Figure 2. Distribution of synthetic values of the physical indicators for each player

Analysis of relationship types between anthropometric and physical indicators

Being a result of associating anthropometric and physical indicators, the relational indicator does not show the athletes' performance but rather provides information regarding the children's harmonious and balanced development after participating in trainings. After analyzing the relationships between anthropometric and physical indicators on the level of the target group studied (18 children registered in the football team, 2012 generation) during 2022-2025, based on the analyzed variables, it was revealed the existence of the following relationship types:

(1) Weak negative relationships, characterized by values of the relational indicator between -1 and -0.5, were established in 6 cases (8.3%), 1 case in 2022, for player 15, 2 cases in 2023, players 15 and 18, 1 case in 2024, player 10 and 2 cases in 2025, players 7 and 16. This type of relationship is characterized by synthetic values of anthropometric indicators that are lower than those of physical indicators. Thus, the relational indicator for player 15 in 2022 was -0.677, based on the synthetic values of the anthropometric indicator (0.115) and the physical indicator (0.594) (Figure 3).

(2) Strong negative relationships, with values of the relational indicator between -0.50 and 0, were identified in 44 cases (61.1%), 11 in 2022, 10 in 2023, 11 in 2024 and 12 in 2025. This relationship type is characterized by values of anthropometric indicators that are lower than those of physical indicators. Thus, for player 2, in 2022, the synthetic value of the anthropometric indicator was 0.291, while the synthetic value of his physical indicator was 0.441 (Figure 3).

(3) Strong positive relationships, with values of the relational indicator between 0 and 0.5, were identified in 21 cases (29.2%), 5 in 2022, 6 in 2023, 6 in 2024 and 4 in 2025. This relationship type is characterized by higher values of anthropometric indicators than of physical indicators. Thus, for player 17, in 2022, the synthetic value of his anthropometric indicator was 0.404, while that of his physical indicator was 0.367 (Figure 3).

(4) Weak positive relationship, with values of the relational indicator between 0.5 and 1, were identified in only 1 case (1.4%), player 1 in 2022. This relationship type is characterized by higher values of anthropometric indicators than of physical indicators. Thus, for player 1, in 2022, the synthetic value of his anthropometric indicator was 0.573, while that of his physical indicator was 0.176 (Figure 3).

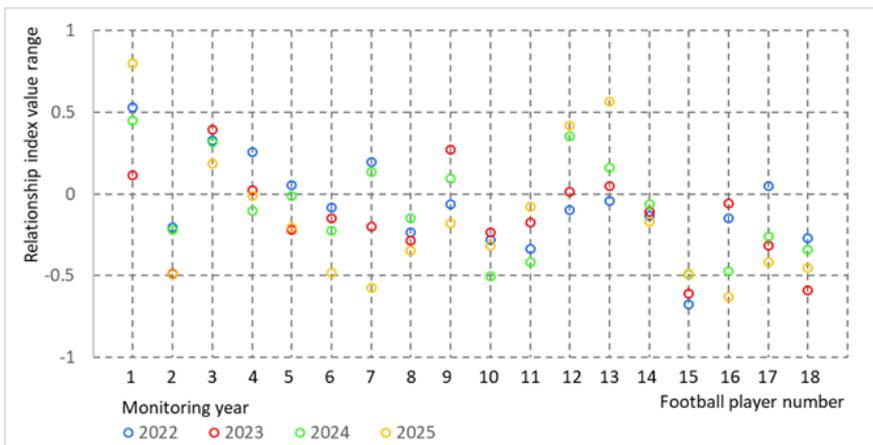


Figure 3. Distribution of relationship types between the synthetic anthropometric and physical indicators for each player

The strongest negative relationships between anthropometric and physical indicators were observed among the following players: player 13 (2022), player 5 (2024), and player 4 (2025). These were the negative relationships which emphasized the role of physical indicators in relation to the anthropometric ones. Thus, player 13 had a relationship indicator value of -0.040 in 2022, conditioned by the synthetic values of the anthropometric indicator (0.422) and the physical indicator (0.457). The strongest positive relationships were observed for players 17 (2022), 4 (2023), and 12 (2023). These were the positive relationships which emphasized the role of anthropometric indicators, in relation to physical ones. For example, for player 17, in 2022, the relationship indicator was of 0.049, being conditioned by the synthetic values of the anthropometric indicator, of 0.404, and the physical one, of 0.367 (Figure 3).

The weakest negative relationships between anthropometric and physical indicators were observed among players 15 (2022 and 2023), 18 (2023), and 16 (2025). These were the negative relationships which emphasized the role of physical indicators in relation to the anthropometric ones. Thus, for player 15, in 2022, the value of the relationship indicator was -0.677, being conditioned by the synthetic values of the anthropometric indicator, of 0.115, and that of the physical indicator, of 0.594. The weakest positive relationships were observed for players 1 (2022, 2024, and 2025), 13 (2025), and 12 (2025). These were the positive relationships which emphasized the role of anthropometric indicators, in relation to physical ones. For example, for player 1, in 2022, the relationship indicator was of 0.529, being conditioned by the synthetic values of the anthropometric indicator, of 0.573, and that of the physical one, of 0.176 (Figure 3).

The analysis of relationship indicator evolution for each player emphasized certain defining features regarding the relationship between the evolution of anthropometric and physical indicators, being closely related to training and its characteristics. Thus, it was noticed the existence of four evolution categories: positive, when the value of the relationship indicator is close to 0 (players 3, 11 and 15); negative, when the value of the relationship indicator is farther from 0 (players 1, 2, 8, 10, 14, 16 and 18); positive-negative, when the value of the relationship indicator is under 0, towards -1 (players 12 and 13); negative-positive, when the value of the relationship indicator is above 0, towards 1 (players 3, 11 and 15). How far or close to 0 the value of the relationship indicator was, was conditioned by the oscillations of the synthetic anthropometric and synthetic values which, in turn, were determined by their defining variables. Between the analyzed variables, there are interconditioned relationships, thus the anthropometric indicators can be influenced both by the physiological particularities and characteristics and age specific to each

child, and by the physical indicators. In contrast, physical indicators can be influenced by anthropometric indicators and the particularities specific to training and lifestyle (Figure 3).

The analysis of tendency of relationship types (according to the value range -1 and 1), for each player showed the following typologies: constant tendency (7 players, 38.9%), ascendant tendency (4 players, 22.2%), descendent tendency (3 players, 16.7%) and oscillating tendency (4 players, 22.2%).

The analysis of relationship evolution between anthropometric and physical indicators of the target group members during 2022-2025 showed the existence of a relatively constant situation, characterized by small oscillations caused by the increase and decrease of physical and anthropometric indicators' values of the analyzed players (Figure 4).

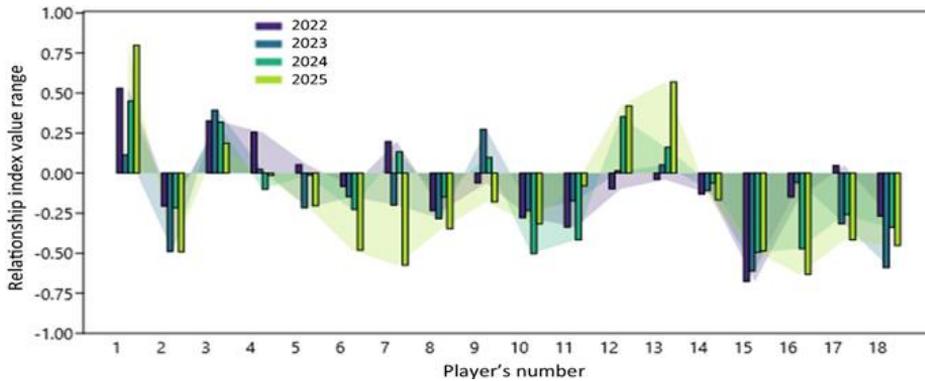


Figure 4. Evolution of relationships between anthropometric and physical indicators, for each player

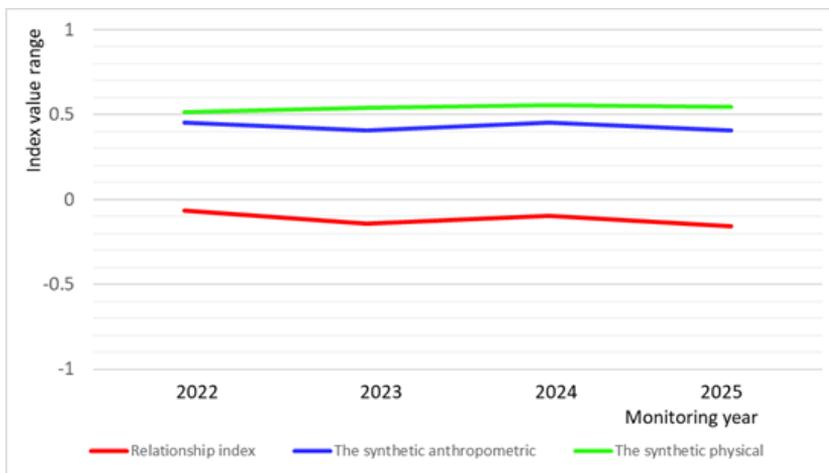


Figure 5. Evolution of average values of relationships between anthropometric and physical indicators, on team level

The analysis of the average values of relationship indicators on target group level, 2022-2025, showed the existence of certain values specific to strong negative relationships, which shows the importance of physical indicators in relation to the anthropometric ones. This is also explained through the role and importance of training carried out in the 2022–2025-time interval (Figure 5).

Discussion

The identification and exploration of relationships between the anthropometric and physical indicators in case of children is a complex and, at the same time, necessary approach. The complexity derives from the physiological characteristics specific to the analyzed age (from 10 to 13). In contrast, necessity derives from the importance of practicing sports for health (with implications on the anthropometric indicators) and achieving athletic performance.

According to Malina & Bouchard (2004), the anthropometric indicators – especially height, weight and mass-height ratio – reflect biological maturity level, a crucial element in selection and training planning of children and teenagers. Reilly & Doran (2003) point out that, in football, body proportions influence the type of preferential effort and players' specialization on positions: players with euhomomorphic somatic indicators show advantages in speed and agility, while players with a stronger mesomorphic component excel in duels and physical endurance. Carter & Heath (1990) demonstrated that the analysis of body composition and growth indicators allows the individualization of training programs, optimization of muscle development and decrease of overload risk.

Physical performance is directly dependent on the body's capacity to transform and use energy (Bompa et al., 2019). Measuring speed, resistance and strength provide objective data about training efficiency and motor training level. According to Bangsbo (1994), the speed and resistance parameters are crucial in modern football where it is estimated that a professional player performs between 1,000 and 1,500 direction changes per game, and over 90% of the actions last under 6 seconds – aspects which require constant monitoring of anaerobic and aerobic capacity. Reilly (2007) recommends the periodical assessment of strength and resistance indicators of young athletes, emphasizing that the functional muscle strength development contributes not only to performance, but to injury prevention, as well, on knee and ankle level.

The obtained results add to the specialty literature, emphasizing the importance of trainings in improving athletes' metabolic and cardiovascular functions (Foster et al., 2015; Laursen & Buchheit, 2019; Kunz et al., 2019), in developing resistance and team performance (Manuel Clemente et al., 2021; Chen et al., 2022).

The methodology and the limitations of the indicators used conditioned the results. Amongst the strong points, the observation period stands out (between 2022 and 2025), while amongst the weaknesses, we mention: the limited number of variables (4 variables for the anthropometric indicators and 5 for the physical ones); the limited number of accomplished measurements (once a year); the lack of information regarding players' consistency in trainings, motivation for practicing sports, life style (nutrition, rest, other aspects).

Our results confirm the importance of sports training, the average value of the relationship indicator for the players, during the 4 years analyzed, was within the 0 and -0.5 range, which shows the existence of strong negative relationships, with the preponderance of the physical indicators' values. There were also noticed oscillations and deviations from the average, for each player being conditioned by the evolution of analyzed indicators' variables which, in turn, can be conditioned by other factors, not included in the study.

Considering all these aspects, new approaches are required in the future, regarding the necessity of accomplishing some comparative studies by extending the target group to children who do not practice sports; extending the studies regarding the relationship between anthropometric and physical indicators by including new indicators; analysis of motivation, satisfaction and perception of sports in society, school and of each player, etc.

Conclusion

Sport is an activity with beneficial effects on health and harmonious body development and motor skills. The performance obtained from practicing sports is determined by anthropometric indicators (height, body weight, thoracic elasticity and vital pulmonary capacity) and physical ones (speed, resistance, abdominal strength, upper limbs' strength and lower limbs' strength of the studied group). Amongst these indicators, interconditioning relationships develop, so as each of them influences and is influenced.

In this context, the results obtained from the study confirm the research hypothesis regarding the existence of strong relationships between the anthropometric and physical indicators in 65 cases during the analyzed period, 2022-2025, (90.3%), while only in 7 cases (9.7%) were preponderant the weak relationships. Of the 65 cases, 44 showed strong negative relationships, in which the physical indicators' values were higher than those of the anthropometric indicators. Other very important analyzed aspects were the evolution of the relationship indicator for each player and the tendency of relationship type depending on the value range -1 and 1, on player level, which provided crucial information regarding the characteristics of the anthropometric and physical indicators' evolution. Based on this

information, evolution predictions can be made and the training can be personalized according to the players' individual needs, to improve sports performance. Therefore, considering the tendency of relationship types depending on the difference between values within the -1 and 1 range, it is recommended: a personalized training approach for the players defined by negative tendency (44.4%); maintaining the training type for the players with positive tendency (16.7%); identifying the factors which can lead to a more efficient training and performance improvement for players with oscillating tendencies (38.9%).

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