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Motor Performance and Field Based Physical Fitness Correlates of 505 Change of Direction Performance in 9 to 10 Year Old Children: An Exploratory Cross Sectional Study

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Abstract

Background

Field based physical fitness tests are widely used to describe motor performance in school age children, but the motor and anthropometric correlates of change of direction tasks during late childhood remain incompletely described. The 505 change of direction (COD) test captures a pre planned movement task that requires acceleration, deceleration, turning, and reacceleration. This study examined motor performance and field based physical fitness correlates of 505 COD performance in 9 to 10 year old children.

Methods

This exploratory cross-sectional study included 98 apparently healthy school age children (55 boys and 43 girls). The 505 COD time was used as the outcome variable. Candidate field based variables included 20 m sprint time, back leg strength, handgrip strength, squat jump, simple visual reaction time, flexibility tests, and selected anthropometric indices. Sex stratified correlations were interpreted with Benjamini-Hochberg false discovery rate (FDR) q values. Exploratory regression models were intentionally conservative and should be interpreted as within sample explanatory models rather than validated prediction tools.

Results

Across boys and girls, 20 m sprint time was the most consistent correlate of 505 COD time. In boys, the model including 20 m sprint time and back leg strength explained 39.8% of the variance in 505 COD time (adjusted R2 = 0.375). In girls, the conservative model including 20 m sprint time and simple visual reaction time explained 58.9% of the variance (adjusted R2 = 0.568). A sensitivity model including shoulder hip ratio explained 63.3% of the variance but was interpreted cautiously because shoulder hip ratio was not a significant bivariate correlate of 505 COD time.

Conclusions

In school age children, linear sprint performance was the most consistent field based correlate of 505 COD performance. Strength related measures in boys and general neuromotor response time in girls provided additional explanatory information, but the findings are exploratory. The models should not be used as clinical, screening, or individual level prediction tools without further validation in larger pediatric samples with maturation, habitual physical activity, sport participation, and reliability data.

Background

Physical fitness and motor performance are important components of child health and development. In school age children, field based physical fitness tests are frequently used because they are feasible, inexpensive, and suitable for school and community settings. Measures of speed, muscular strength, flexibility, jumping performance, and body size can provide practical information about children's functional movement capacity and may also help identify areas that require further assessment or support. Previous reviews and large reference datasets indicate that physical fitness in childhood is associated with current and future health indicators, supporting the value of simple field based assessment in pediatric and school settings [1–4].

Motor competence is not limited to isolated strength or speed tasks. It also includes the ability to coordinate movement, control the body during acceleration and deceleration, and rapidly redirect movement in a planned or semi planned context. These capacities are relevant to physical education, daily play, and participation in age appropriate physical activity. Developmental and systematic review evidence suggests that motor competence is closely linked with physical activity, health related fitness, and broader developmental trajectories, although the strength and direction of these relationships may vary by age, sex, and assessment method [5–11].

The 505 COD test is commonly used to describe pre planned change of direction performance. In this task, the child accelerates, decelerates, turns 180 degrees, and reaccelerates through a timing area. Although the test has often been discussed in sport performance literature, it can also be interpreted more broadly as a field based motor performance task that combines linear speed, braking control, turning ability, and reacceleration. Importantly, the 505 test does not measure reactive agility because it does not require a response to an unpredictable external stimulus; this distinction is central when interpreting findings in pediatric samples [12–18].

Late childhood is a relevant period for examining field based correlates of COD performance. During this period, children are undergoing changes in body proportions, neuromuscular coordination, muscular strength, flexibility, and movement control. Chronological age alone may not fully capture developmental status because biological maturation and growth tempo can influence strength, sprinting, jumping, and COD related tasks. Sex related differences in explosive actions and movement performance may begin to emerge during late childhood, but such patterns require cautious interpretation when maturity status and sport participation history are not measured [19–24].

Several field based measures may be linked to 505 COD performance. Linear sprint time is likely to be related because part of the 505 test involves acceleration and reacceleration. Muscular fitness may reflect the capacity to control body mass during braking and redirection, whereas body size and body proportions may influence movement mechanics. In pediatric contexts, these variables should be considered as field based physical fitness correlates rather than direct causal determinants, especially when longitudinal data, maturation indicators, and intervention evidence are unavailable [25–29].

Previous studies have examined predictors of agility or COD performance mainly in adolescent athletes or sport specific samples. Fewer studies have framed 505 COD performance as a field based motor

performance outcome in school age children. This distinction is important for pediatric readers because the aim is not to identify athletic talent or produce a validated individual prediction equation. Instead, the present study uses an exploratory cross sectional framework to describe which accessible field based physical fitness variables are associated with 505 COD performance in 9 to 10 year old children.

The primary aim of this study was to examine motor performance and field based physical fitness correlates of 505 COD performance in school age children. A secondary aim was to explore whether the pattern of associations differed when boys and girls were analysed separately. Because the sample was modest and no internal or external validation was available, all regression models were interpreted as exploratory, hypothesis generating explanatory models rather than validated prediction tools.

Methods

Study design and setting

This was an exploratory cross sectional study conducted in a school based field testing setting. The outcome variable was 505 COD test time, which was used to describe pre planned change of direction motor performance. The study focused on field based physical fitness and anthropometric correlates that can be assessed in school or community settings. The study was not designed to develop a clinical screening tool, an individual level prediction equation, or a talent identification model.

All measurements were completed over two testing days. On the first day, anthropometric measurements, flexibility tests, and the 505 COD test were performed. On the second day, simple visual reaction time, 20 m sprint, handgrip strength, and back and leg strength were assessed. The archived protocol confirmed two trial testing for the main field tests; however, complete manufacturer/model information for the timing gates and detailed warm up and rest durations were not available in the analysis file. This is reported as a limitation because it reduces reproducibility.

Participants

The study included 98 apparently healthy children aged 9 to 10 years, comprising 55 boys and 43 girls. Participants were included if they were apparently healthy, had no known chronic disease or musculoskeletal condition that would limit physical performance testing, and were able to complete the field based test battery. Children with acute injury, pain during testing, or incomplete data for the core outcome were excluded from the relevant analyses.

The study was approved by the Ethics Committee of Bandirma Onyedi Eylul University (approval code: E-25691463-050.04-2500066071-2025-139). Written informed consent was obtained from parents or legal guardians, and age-appropriate verbal assent was obtained from the children before participation. The study was conducted in accordance with the principles of the Declaration of Helsinki and contemporary ethical standards for sport and exercise science research [30].

Anthropometric measurements

Body height and body mass were measured with participants barefoot and wearing light sport clothing. Height was measured to the nearest 0.1 cm, and body mass was measured to the nearest 0.1 kg. Body mass index (BMI) was calculated as body mass divided by height squared (kg/m2). Triponderal mass index (TMI) was calculated as body mass divided by height cubed (kg/m3), as TMI has been proposed as a useful index in pediatric body size assessment [29]. Waist and hip circumferences were measured in standing position, and waist to hip ratio was calculated from valid values only [31]. Shoulder hip ratio and intermembral index were used as exploratory anthropometric indices.

Field based physical fitness and motor performance tests

Linear sprint performance was assessed using a 20 m sprint test. Participants started from a standing position and completed two trials; the fastest valid time was used for analysis. Sprint time was recorded in seconds using photocell timing gates available in the field testing setting. The manufacturer and model of the timing system were not retrievable from the archived analysis file.

Handgrip strength was measured separately for the right and left hands using a Takei hand dynamometer. Participants stood upright with the tested arm held freely at the side. Back and leg strength was assessed using a Takei Back-D dynamometer. Squat jump height was measured using the My Jump Lab mobile application, which has been used in field based vertical jump assessment [32]. Flexibility was assessed using the sit and reach test and a trunk and neck static flexibility test. Simple visual reaction time was assessed using a computer based protocol in which participants responded to visual stimuli as quickly as possible [33, 34].

The 505 test was used to assess pre planned COD performance. Participants accelerated toward a turning line, performed a 180 degree turn, and returned through the timing area. The fastest valid time from two trials was used for analysis. The test was interpreted as a pre planned COD task that involves acceleration, deceleration, turning, and reacceleration, and not as a reactive agility assessment [12–18]. Previous work has also emphasized the importance of test-retest reliability and measurement standardization in COD, sprint, strength, and jump assessments [35–39].

Statistical analysis

Descriptive statistics are presented as mean, standard deviation, and minimum maximum values. Analyses were performed separately for boys and girls because the study aimed to describe sex stratified exploratory patterns. Pearson correlation coefficients were calculated to describe linear associations between 505 COD time and candidate field based variables. Because multiple correlations were examined, Benjamini-Hochberg false discovery rate (FDR) q values were calculated within each sex [40, 41]. These analyses were exploratory and were not used to make confirmatory claims.

Multiple linear regression analyses were performed with 505 COD time as the outcome variable. Model selection was deliberately conservative and based on theoretical relevance, bivariate association patterns, and avoidance of excessive model complexity in the sex stratified samples. In boys, the primary exploratory model included 20 m sprint time and back leg strength. In girls, the primary conservative model included 20 m sprint time and simple visual reaction time. A sensitivity model adding Shoulder hip ratio was reported only for transparency because this variable was significant after adjustment but was not a significant bivariate correlate of 505 COD time.

Model fit was reported using R2, adjusted R2, F statistics, p values, and the standard error of the estimate. Regression coefficients were reported as unstandardized B, standard error, 95% confidence interval, standardized beta, p value, and variance inflation factor. The models were not internally or externally validated. Therefore, explained variance values should be interpreted as within sample descriptive estimates rather than as evidence of generalisable prediction performance. Reporting of the observational design was informed by STROBE guidance [42, 43].

Results

The final dataset included 98 children: 55 boys and 43 girls. Descriptive characteristics and field based physical fitness measures are presented in Table 1. Boys had a mean 505 COD time of 3.41 ± 0.34 s and a mean 20 m sprint time of 4.41 ± 0.32 s. Girls had a mean 505 COD time of 3.72 ± 0.39 s and a mean 20 m sprint time of 4.82 ± 0.49 s.

Table 1
Descriptive characteristics and field based physical fitness measures

Variable	Boys n	Boys mean ± SD	Boys min-max	Girls n	Girls mean ± SD	Girls min-max
505 COD time (s)	55	3.41 ± 0.34	2.30–4.51	43	3.72 ± 0.39	3.18–5.27
20 m sprint time (s)	55	4.41 ± 0.32	3.79–5.11	43	4.82 ± 0.49	4.05–6.03
Simple visual reaction time (s)	55	0.35 ± 0.13	0.14–0.92	43	0.38 ± 0.15	0.16–0.87
Back leg strength (kg)	55	41.53 ± 12.36	21.50–72.50	43	39.45 ± 13.49	20.00–73.00
Shoulder hip ratio	55	1.36 ± 0.10	1.11–1.61	43	1.32 ± 0.11	0.85–1.54
Sit and reach (cm)	55	20.45 ± 6.77	5.00-33.50	43	24.92 ± 7.62	6.00-37.50
Squat jump (cm)	55	22.67 ± 5.52	12.95–35.89	43	20.38 ± 5.52	11.48–37.30
Right handgrip strength (kg)	55	13.38 ± 2.63	8.60–21.30	43	11.89 ± 3.07	5.00–20.00
Left handgrip strength (kg)	55	13.25 ± 2.43	8.90–20.40	43	12.24 ± 2.89	6.60–17.90
Static flexibility-trunk/neck (cm)	55	30.67 ± 9.72	15.00–67.00	43	32.07 ± 9.10	13.00–62.00
BMI (kg/m²)	55	17.93 ± 3.33	12.00-26.45	43	18.13 ± 3.29	13.18–27.30
TMI (kg/m³)	55	13.21 ± 2.18	9.48–19.23	43	13.37 ± 2.09	10.00-18.63
Intermembral index (%)	55	122.28 ± 7.63	96.43-139.66	43	120.61 ± 6.58	108.70-134.04
WHR	52	0.84 ± 0.03	0.77–0.93	43	0.82 ± 0.05	0.73–0.93
Pelvic index (%)	55	92.95 ± 6.16	71.43-102.31	43	91.59 ± 6.60	69.43-102.02

Values are presented as mean ± standard deviation and minimum-maximum. WHR was summarised using valid values only in boys (n = 52) because two waist/hip calculations were missing and one implausible WHR value was excluded from the descriptive summary. COD, change of direction; SD, standard deviation; BMI, body mass index; TMI, triponderal mass index; WHR, waist to hip ratio.

Sex stratified bivariate correlations with 505 COD time are shown in Table 2. In both sexes, 20 m sprint time was the most consistent positive correlate of 505 COD time. Back leg strength, squat jump, and handgrip strength showed negative associations with COD time in boys. In girls, 20 m sprint time, back

leg strength, sit and reach, and handgrip strength showed associations with 505 COD time. After FDR adjustment, the simple visual reaction time association was weaker and was interpreted cautiously.

Table 2
Sex stratified correlations with 505 COD time

Variable	Boys r	Boys p	Boys FDR q	Girls r	Girls p	Girls FDR q
20 m sprint time (s)	0.568	< 0.001	< 0.004	0.721	< 0.001	< 0.004
Back leg strength (kg)	-0.332	0.013	0.035	-0.426	0.004	0.009
Simple visual reaction time (s)	0.102	0.459	0.524	0.313	0.041	0.055
Shoulder hip ratio	0.060	0.663	0.663	-0.252	0.103	0.103
Sit and reach (cm)	-0.160	0.243	0.324	-0.563	< 0.001	< 0.004
Squat jump (cm)	-0.455	< 0.001	< 0.004	-0.296	0.054	0.062
Left handgrip strength (kg)	-0.318	0.018	0.036	-0.475	0.001	0.003
Right handgrip strength (kg)	-0.302	0.025	0.040	-0.350	0.021	0.034

Values are Pearson correlation coefficients. Positive r values indicate longer 505 COD time with higher values of the variable; negative r values indicate shorter 505 COD time with higher values. FDR q-values were calculated using the Benjamini-Hochberg procedure within each sex. Analyses were exploratory and should not be interpreted as confirmatory multiple-comparison testing.

Figure 1 illustrates the association between 20 m sprint time and 505 COD time. The direction of the association was similar in boys and girls, supporting the role of linear sprint performance as the most consistent field based correlate of 505 COD time in this sample.

Figure 1. Association between 20 m sprint time and 505 COD time by sex.

Scatter points represent individual participants, and fitted regression lines show the sex stratified association between 20 m sprint time and 505 COD time. The figure is descriptive and does not indicate a validated prediction equation.

The exploratory regression models are presented in Table 3. In boys, the model including 20 m sprint time and back leg strength was significant and explained 39.8% of the variance in 505 COD time. In girls, the conservative primary model including 20 m sprint time and simple visual reaction time explained 58.9% of the variance. The sensitivity model that additionally included Shoulder hip ratio explained 63.3% of the variance, but this result should be interpreted cautiously because Shoulder hip ratio was not a significant bivariate correlate of 505 COD time.

Table 3
Exploratory regression models for 505 COD time

Model	Variable	B	SE	95% CI	β	p	VIF
Boys primary model	20 m sprint time (s)	0.572	0.115	0.342 to 0.802	0.539	< 0.001	1.01
	Back leg strength (kg)	-0.008	0.003	-0.013 to -0.002	-0.277	0.014	1.01
Girls primary conservative model	20 m sprint time (s)	0.564	0.082	0.399 to 0.729	0.702	< 0.001	1.01
	Simple visual reaction time (s)	0.677	0.262	0.148 to 1.207	0.263	0.013	1.01
Girls sensitivity model	Shoulder hip ratio	-0.788	0.366	-1.528 to -0.048	-0.224	0.038	1.14
	20 m sprint time (s)	0.527	0.080	0.365 to 0.688	0.656	< 0.001	1.06
	Simple visual reaction time (s)	0.852	0.264	0.319 to 1.385	0.330	0.003	1.11

Boys primary model: R2 = 0.398, adjusted R2 = 0.375, F(2,52) = 17.20, p < 0.001, standard error of estimate = 0.267. Girls primary conservative model: R2 = 0.589, adjusted R2 = 0.568, F(2,40) = 28.66, p < 0.001, standard error of estimate = 0.256. Girls sensitivity model: R2 = 0.633, adjusted R2 = 0.604, F(3,39) = 22.39, p < 0.001, standard error of estimate = 0.245. CI, confidence interval; VIF, variance inflation factor. The sensitivity model is reported for transparency and should not be interpreted as a validated prediction model.

Figure 2 presents standardized regression coefficients from the primary exploratory models. Across both sex groups, 20 m sprint time had the largest positive standardized coefficient. The coefficients describe within sample explanatory associations and should not be interpreted as externally validated individual level prediction effects.

Figure 2. Standardized coefficients from the primary exploratory models.

Dots represent standardized coefficients (β), and horizontal bars represent approximate 95% confidence intervals transformed from unstandardized confidence intervals. Positive coefficients indicate longer 505 COD time, whereas negative coefficients indicate shorter 505 COD time.

Discussion

This exploratory cross sectional study reframed 505 COD performance as a field based motor performance outcome in school age children. The main finding was that 20 m sprint time was the most consistent correlate of 505 COD time in both boys and girls. This is expected because the 505 test

includes acceleration and reacceleration components. However, the finding is still useful in a pediatric field testing context because it indicates that a simple linear sprint test captures a substantial part of the variance in a more complex turning task.

The present results should be interpreted as associations between field based physical fitness measures and a motor performance task, not as evidence of causation. Children who performed better in the 20 m sprint also tended to complete the 505 COD test faster. This may reflect shared neuromuscular and mechanical requirements, including rapid force production, step frequency, acceleration capacity, and efficient reacceleration after turning. However, the 505 test also requires deceleration and directional control, which may explain why strength related variables contributed additional information in boys [18, 44–47].

In boys, back leg strength contributed to the exploratory model after 20 m sprint time. This suggests that general lower body strength may be relevant to tasks that require braking and redirection of body mass. Muscular fitness is an important component of pediatric physical fitness, but because no test-retest reliability indices and no maturation data were available, this result should be interpreted as a within sample association. It should not be used to infer that increasing back leg strength alone would improve COD performance in school age boys [25–28].

In girls, 20 m sprint time was again the dominant field based correlate. Simple visual reaction time added explanatory information in the conservative model, but this result requires caution. The 505 test is a pre planned task and does not require reactive decision making. Therefore, simple visual reaction time should be viewed as a general neuromotor response measure rather than a task specific determinant of 505 COD performance [12–15].

The sensitivity model including Shoulder hip ratio is reported for transparency but should not be overinterpreted. Shoulder hip ratio was not a significant bivariate correlate of 505 COD time, and its contribution after adjustment may reflect sample specific suppression, residual confounding, or statistical instability. This finding requires replication in larger pediatric samples with more complete information on growth, maturation, and body composition [19, 20].

The study has relevance for pediatric and school based assessment because it uses feasible tests that can be administered outside specialised laboratories. Field based fitness testing is important in child health and physical education, but interpretation should be developmentally appropriate. In this context, the results may help researchers and practitioners understand which general fitness domains are associated with a complex turning task. The results should not be used to rank children clinically, select athletic talent, or create individual level screening thresholds [1–11].

Several limitations should be noted. First, the cross sectional design prevents causal interpretation. Second, biological maturation, growth tempo, habitual physical activity, organised sport participation, and socioeconomic factors were not measured. These variables may influence both field based fitness measures and 505 COD performance. Third, the sample was modest, particularly after sex stratification,

and the models were not internally or externally validated. Fourth, test-retest reliability indices such as intraclass correlation coefficients, standard error of measurement, and coefficients of variation were not available. Fifth, complete equipment information for the photocell timing system and detailed warm up and rest intervals were not retrievable from the archived dataset. These limitations mean that the findings should be considered hypothesis generating [19, 20, 37–43].

Future studies should include larger and more diverse school age samples, formal maturation assessment, habitual physical activity data, sport participation history, and standardized reliability testing. Prospective studies are needed to determine whether changes in sprint, strength, or flexibility measures correspond to changes in COD performance over time. Validation studies should also evaluate whether explanatory models remain stable across schools, age groups, and developmental stages [19, 20, 37–43].

Conclusions

In 9 to 10 year old children, 20 m sprint time was the most consistent field based physical fitness correlate of 505 COD performance. Back leg strength in boys and simple visual reaction time in girls provided additional explanatory information in conservative exploratory models. The findings should be interpreted as descriptive, within sample associations rather than validated prediction effects. More comprehensive pediatric studies incorporating maturation, habitual physical activity, sport participation, measurement reliability, and external validation are needed before these associations can be applied in screening, intervention planning, or individual level decision making.

Abbreviations

BMI
body mass index
COD
change of direction
CI
confidence interval
FDR
false discovery rate
SD
standard deviation
SVRT
simple visual reaction time
TMI
triponderal mass index
VIF
variance inflation factor

WHR
waist to hip ratio.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee of Bandirma Onyedi Eylul University (approval code: E-25691463-050.04-2500066071-2025-139). Written informed consent was obtained from parents or legal guardians, and age appropriate verbal assent was obtained from the children before participation. The study was conducted in accordance with the principles of the Declaration of Helsinki and contemporary ethical standards for sport and exercise science research [30].

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Authors' information

Not applicable.

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Author Contribution

KU, SNM, SD, GB, OBA, OO, YA, HD, and VVG contributed to study conception, data collection, analysis, manuscript drafting, critical revision, and approval of the final manuscript. All authors read and approved the final manuscript.

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Data Availability

The datasets generated and/or analysed during the current study are not publicly available due to participant privacy and ethical considerations involving minors, but are available from the corresponding author upon reasonable request.

References

1. Ortega FB, Ruiz JR, Castillo MJ, Sjostrom M. Physical fitness in childhood and adolescence: a powerful marker of health. Int J Obes (Lond). 2008;32(1):1–11. 10.1038/sj.ijo.0803774.
2. Ruiz JR, Castro-Pinero J, Artero EG, Ortega FB, Sjostrom M, Suni J, et al. Predictive validity of health-related fitness in youth: a systematic review. Br J Sports Med. 2009;43(12):909–23. 10.1136/bjsm.2008.056499.
3. Tomkinson GR, Carver KD, Atkinson F, Daniell ND, Lewis LK, Fitzgerald JS, et al. European normative values for physical fitness in children and adolescents aged 9–17 years: results from 2,779,165 Eurofit performances representing 30 countries. Br J Sports Med. 2018;52(22):1445–56. 10.1136/bjsports-2017-098253.
4. Ortega FB, Leskosek B, Blagus R, Gil-Cosano JJ, Maestu J, Tomkinson GR, et al. European fitness landscape for children and adolescents: updated reference values, fitness maps and country rankings based on nearly 8 million test results from 34 countries gathered by the FitBack network. Br J Sports Med. 2023;57(5):299–310. 10.1136/bjsports-2022-106176.
5. Stodden DF, Goodway JD, Langendorfer SJ, Roberton MA, Rudisill ME, Garcia C, et al. A developmental perspective on the role of motor skill competence in physical activity: an emergent relationship. Quest. 2008;60(2):290–306. 10.1080/00336297.2008.10483582.
6. Robinson LE, Stodden DF, Barnett LM, Lopes VP, Logan SW, Rodrigues LP, et al. Motor competence and its effect on positive developmental trajectories of health. Sports Med. 2015;45(9):1273–84. 10.1007/s40279-015-0351-6.
7. Barnett LM, van Beurden E, Morgan PJ, Brooks LO, Beard JR. Childhood motor skill proficiency as a predictor of adolescent physical activity. J Adolesc Health. 2009;44(3):252–9. 10.1016/j.jadohealth.2008.07.004.
8. Lubans DR, Morgan PJ, Cliff DP, Barnett LM, Okely AD. Fundamental movement skills in children and adolescents: review of associated health benefits. Sports Med. 2010;40(12):1019–35. 10.2165/11536850-000000000-00000.
9. Cattuzzo MT, Henrique RS, Re AH, Oliveira IS, Melo BM, Moura MS, et al. Motor competence and health related physical fitness in youth: a systematic review. J Sci Med Sport. 2016;19(2):123–9. 10.1016/j.jsams.2014.12.004.
10. Utesch T, Bardid F, Busch D, Strauss B. The relationship between motor competence and physical fitness from early childhood to early adulthood: a meta-analysis. Sports Med. 2019;49(4):541–51. 10.1007/s40279-019-01068-y.

11. Barnett LM, Lai SK, Veldman SLC, Hardy LL, Cliff DP, Morgan PJ, et al. Correlates of gross motor competence in children and adolescents: a systematic review and meta-analysis. Sports Med. 2016;46(11):1663–88. 10.1007/s40279-016-0495-z.
12. Sheppard JM, Young WB. Agility literature review: classifications, training and testing. J Sports Sci. 2006;24(9):919–32. 10.1080/02640410500457109.
13. Young W, Farrow D. A review of agility: practical applications for strength and conditioning. Strength Cond J. 2006;28(5):24–9.
14. Draper JA, Lancaster MG. The 505 test: a test for agility in the horizontal plane. Aust J Sci Med Sport. 1985;17(1):15–8.
15. Nimphius S, Callaghan SJ, Bezodis NE, Lockie RG. Change of direction and agility tests: challenging our current measures of performance. Strength Cond J. 2018;40(1):26–38. 10.1519/SSC.0000000000000309.
16. Ryan C, Uthoff A, McKenzie C, Cronin J. New perspectives of the traditional and modified 5-0-5 change of direction test. Strength Cond J. 2022;45(1):83–92. 10.1519/SSC.0000000000000723.
17. Sugiyama T, Maeo S, Kurihara T, Kanehisa H, Isaka T. Change of direction speed tests in basketball players: a brief review of test varieties and recent trends. Front Sports Act Living. 2021;3:645350. 10.3389/fspor.2021.645350.
18. Hewit J, Cronin J, Button C, Hume P. Understanding deceleration in sport. Strength Cond J. 2011;33(1):47–52. 10.1519/SSC.0b013e3181fbd62c.
19. Malina RM, Bouchard C, Bar-Or O. Growth, maturation, and physical activity. 2nd ed. Champaign: Human Kinetics; 2004.
20. Mirwald RL, Baxter-Jones AD, Bailey DA, Beunen GP. An assessment of maturity from anthropometric measurements. Med Sci Sports Exerc. 2002;34(4):689–94. 10.1097/00005768-200204000-00020.
21. Meylan CMP, Cronin JB, Oliver JL, Rumpf MC. Sex-related differences in explosive actions during late childhood. J Strength Cond Res. 2014;28(8):2097–104. 10.1519/JSC.0000000000000377.
22. Lloyd RS, Oliver JL. The youth physical development model: a new approach to long-term athletic development. Strength Cond J. 2012;34(3):61–72. 10.1519/SSC.0b013e31825760ea.
23. Thieschafer L, Busch D. Development and trainability of agility in youth: a systematic scoping review. Front Sports Act Living. 2022;4:952779. 10.3389/fspor.2022.952779.
24. Sariati D, Hammami R, Zouhal H, Clark CCT, Nebigh A, Chtara M, et al. Improvement of physical performance following a 6-week change of direction training program in elite youth soccer players of different maturity levels. Front Physiol. 2021;12:759535. 10.3389/fphys.2021.759535.
25. Smith JJ, Eather N, Morgan PJ, Plotnikoff RC, Faigenbaum AD, Lubans DR. The health benefits of muscular fitness for children and adolescents: a systematic review and meta-analysis. Sports Med. 2014;44(9):1209–23. 10.1007/s40279-014-0196-4.

26. Faigenbaum AD, Kraemer WJ, Blimkie CJR, Jeffreys I, Micheli LJ, Nitka M, et al. Youth resistance training: updated position statement paper from the National Strength and Conditioning Association. J Strength Cond Res. 2009;23(5 Suppl):S60–79. 10.1519/JSC.0b013e31819df407.
27. Lloyd RS, Faigenbaum AD, Stone MH, Oliver JL, Jeffreys I, Moody JA, et al. Position statement on youth resistance training: the 2014 International Consensus. Br J Sports Med. 2014;48(7):498–505. 10.1136/bjsports-2013-092952.
28. Till K, Scantlebury S, Jones B. Anthropometric and physical qualities of elite male youth rugby league players. Sports Med. 2017;47(11):2171–86. 10.1007/s40279-017-0745-8.
29. Peterson CM, Su H, Thomas DM, Heo M, Golnabi AH, Pietrobelli A, et al. Tri-ponderal mass index vs body mass index in estimating body fat during adolescence. JAMA Pediatr. 2017;171(7):629–36. 10.1001/jamapediatrics.2017.0460.
30. Harriss DJ, Atkinson G. International Journal of Sports Medicine - ethical standards in sport and exercise science research. Int J Sports Med. 2009;30(10):701–2. 10.1055/s-0029-1237378.
31. Ross R, Neeland IJ, Yamashita S, Shai I, Seidell J, Magni P, et al. Waist circumference as a vital sign in clinical practice: a consensus statement from the IAS and ICCR Working Group on Visceral Obesity. Nat Rev Endocrinol. 2020;16(3):177–89. 10.1038/s41574-019-0310-7.
32. Balsalobre-Fernandez C, Glaister M, Lockey RA. The validity and reliability of an iPhone app for measuring vertical jump performance. J Sports Sci. 2015;33(15):1574–9. 10.1080/02640414.2014.996184.
33. Akarsu S, Caliskan E, Dane S. Athletes have faster eye-hand visual reaction times and higher scores on visuospatial intelligence than nonathletes. Turk J Med Sci. 2009;39(6):871–4. 10.3906/sag-0809-44.
34. Tsiakaras N, Karatrantou K, Batatolis C, Papavasileiou K, Tzeli F, Gerodimos V. Intrasession and intersession reliability of flexibility tests during developmental years: the effects of sport, age, and sex. Sports. 2025;13(8):238. 10.3390/sports13080238.
35. Chen Z, Bian C, Liao K, Bishop C, Li Y. Validity and reliability of a phone app and stopwatch for the measurement of 505 change of direction performance: a test-retest study design. Front Physiol. 2021;12:743800. 10.3389/fphys.2021.743800.
36. Fristrup B, Krustrup P, Kristensen KH, Rasmussen S, Aagaard P. Test-retest reliability of lower limb muscle strength, jump and sprint performance tests in elite female team handball players. Eur J Appl Physiol. 2024;124(9):2577–89. 10.1007/s00421-024-05478-z.
37. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. J Chiropr Med. 2016;15(2):155–63. 10.1016/j.jcm.2016.02.012.
38. Hopkins WG. Measures of reliability in sports medicine and science. Sports Med. 2000;30(1):1–15. 10.2165/00007256-200030010-00001.
39. Atkinson G, Nevill AM. Statistical methods for assessing measurement error (reliability) in variables relevant to sports medicine. Sports Med. 1998;26(4):217–38. 10.2165/00007256-199826040-00002.

40. Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. J R Stat Soc Ser B Stat Methodol. 1995;57(1):289–300. 10.1111/j.2517-6161.1995.tb02031.x.
41. Sainani KL. The problem of multiple testing. PM R. 2009;1(12):1098–103. 10.1016/j.pmrj.2009.10.004.
42. von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. PLoS Med. 2007;4(10):e296. 10.1371/journal.pmed.0040296.
43. Vandenbroucke JP, von Elm E, Altman DG, Gotzsche PC, Mulrow CD, Pocock SJ, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): explanation and elaboration. PLoS Med. 2007;4(10):e297. 10.1371/journal.pmed.0040297.
44. Pojskic H, Aslin E, Krolo A, Jukic I, Uljevic O, Spasic M, et al. Importance of reactive agility and change of direction speed in differentiating performance levels in junior soccer players: reliability and validity of newly developed soccer-specific tests. Front Physiol. 2018;9:506. 10.3389/fphys.2018.00506.
45. Pavlinovic V, Spasic M, Foretic N, Kontic D, Zenic N. Differential influence of general anthropometric and motor predictors on pre-planned agility in pubescent boys and girls: a multiple regression study. Sport Mont. 2022;20(2):75–81. 10.26773/smj.220612.
46. Sekulic D, Spasic M, Esco MR. Predicting agility performance with other performance variables in pubescent boys: a multiple-regression approach. Percept Mot Skills. 2014;118(2):447–61. 10.2466/25.10.PMS.118k16w4.
47. Falch HN, van den Raedergard HG. Effect of different physical training forms on change of direction ability: a systematic review and meta-analysis. Sports Med Open. 2019;5:53. 10.1186/s40798-019-0223-y.

Figures

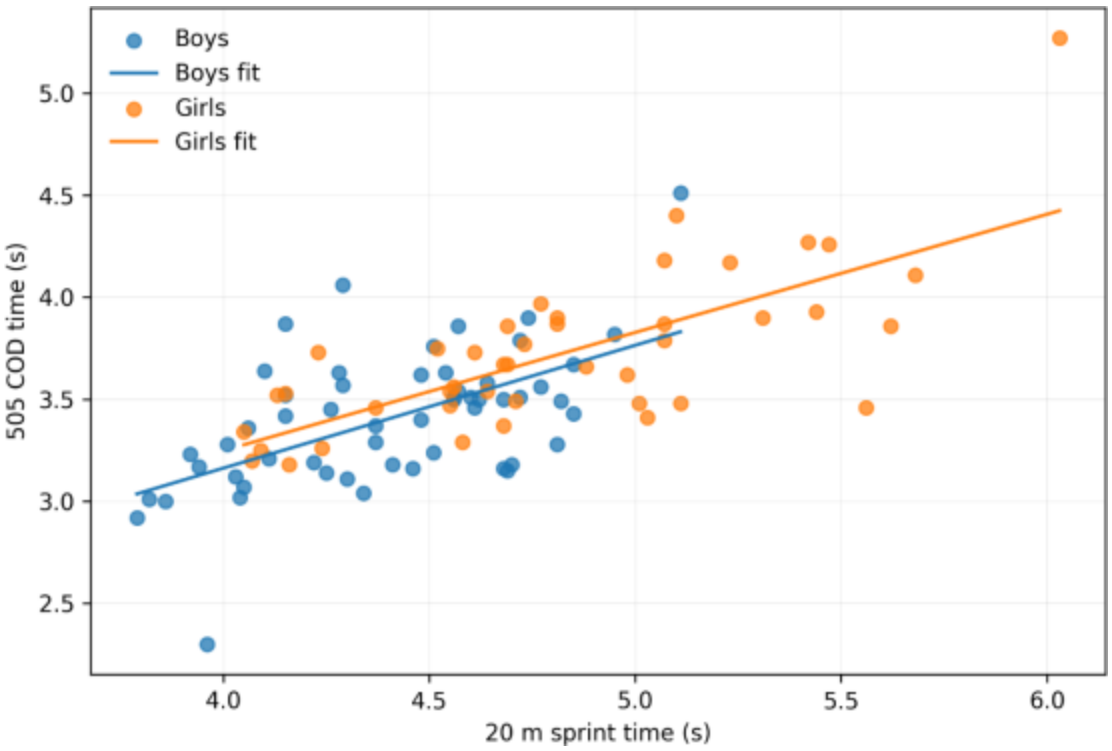


Figure 1

Association between 20 m sprint time and 505 COD time by sex.

Scatter points represent individual participants, and fitted regression lines show the sex stratified association between 20 m sprint time and 505 COD time. The figure is descriptive and does not indicate a validated prediction equation.

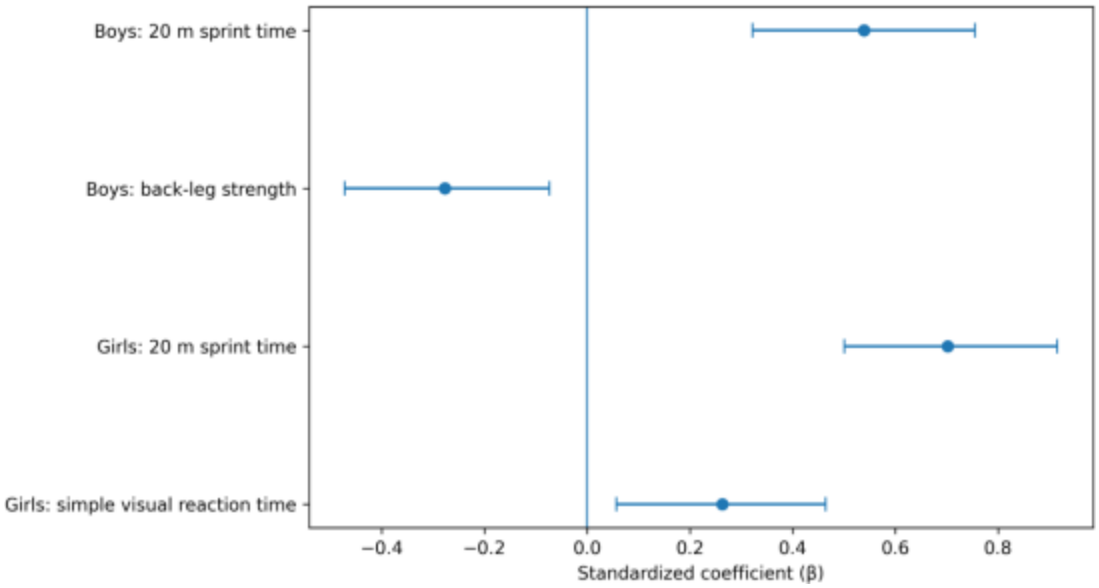


Figure 2

Standardized coefficients from the primary exploratory models.

Dots represent standardized coefficients (β), and horizontal bars represent approximate 95% confidence intervals transformed from unstandardized confidence intervals. Positive coefficients indicate longer 505 COD time, whereas negative coefficients indicate shorter 505 COD time.