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Generic motor abilities and anthropometrics are poorly related to futsal-specific agility performance; multiple regression analysis in professional players

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Abstract

Study aim: This study aimed to evaluate predictors of futsal-specific change-of-direction speed and futsal-specific reactive agility in professional male futsal players.

Material and methods: The players (n=75) studied were members of seven futsal teams that competed at the highest national level in Croatia and in Bosnia and Herzegovina. The predictors in this study included measures of generic power, speed, agility, and anthropometrics. The univariate and multivariate relationships among the predictors and the criteria (futsal-specific change-of-direction speed and futsal-specific reactive agility) were assessed by using Pearson's correlations and multiple regression analysis, respectively.

Results: The predictors were poorly related to the different facets of agility (all trivial to moderate correlations). Multiple regression models were not successfully cross-validated for any of the types of agility performance.

Conclusion: Generic power, speed, agility, and anthropometrics are not valid predictors of futsal-specific change-of-direction speed and futsal-specific reactive agility. As these futsal performances were used to mimic real-game situations in futsal, these findings suggest that superiority in generic motor abilities and anthropometrics may not have a significant effect on performance in futsal matches.

Keywords: Regression modelling – Change of direction speed – Conditioning capacities – Influence

Introduction

Futsal is a complex team sport that is interspersed with rapid changes between high-intensity periods of play and short periods of rest [2, 5, 11]. The structure of the game is characterized by a large number of intense activities, such as sprints, accelerations, decelerations, and rapid changes in direction, which allow players to obtain or maintain ball possession [1, 25]. As the reduced court size put players under constant pressure from opposing players, fast decision making and superior agility capabilities are strictly necessary for keeping or getting the ball [4, 18]. Indeed, research shows that agility is an important determinant of overall success in futsal [8, 18, 28]

Agility has been defined as "a rapid whole-body movement with change of speed or direction in response to a stimulus", and it can be observed in terms of non-reactive agility and reactive agility (RAG) [9, 31]. While non-reactive agility (i.e., pre-planned agility) involves the active change-of-direction speed (CODS) with advance knowledge of the directional change, RAG (i.e., non-planned agility) involves the ability to rapidly change direction while responding to an unpredictable visual and/or audio stimulus [27]. Previous research that investigated the agility of professional futsal players predominantly focused on differences in CODS according to various performance levels [1, 16, 17, 22, 26]. Although the characteristics of the game require players to repeatedly react to external stimuli, such as the ball or an opponent, the RAG performance (which involves reaction to an external stimulus) of futsal players has received little attention to date.

Furthermore, studies have mostly examined generic – not futsal-specific – agility performance, which does not

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appropriately mimic a real-game situation in which one's agility is challenged [25]. Indeed, authors have regularly emphasized that sport-specific testing protocols are more suitable for assessing the physical capacities related to successful performance in a given sport compared to generic fitness tests [3, 13, 25]. In futsal, sport-specific tests that simulate basic movement patterns in real-game situations should involve controlling and dribbling the ball. However, so far, only two studies have utilized such tests to assess CODS and RAG among professional futsal players [26, 28]. Briefly, in their studies, Sekulic et al. aimed to analyse differences in futsal-specific CODS (FS_CODS) and RAG (FS_RAG) according to various performance levels (e.g., juniors vs seniors, starters vs non-starters, top-level vs high-level). The results indicated no differences in futsal-specific CODS and RAG performance between juniors and seniors or starters and non-starters, while top-level players outperformed high-level players in a futsal-specific reactive agility test when dribbling the ball [26, 28].

Evidently, literature regarding futsal-specific agility performance is scarce, while especially lacking the knowledge on associated factors. In general, information on factors associated with futsal-specific agility performance may be highly important in training and conditioning, since it will allow the specific and targeted development of certain capacities, which consequently may improve a real-game situations [12, 19]. Considering physiological background, capacities associated with futsal-specific agility performance may be speed and agility. Namely, both speed and power, and futsal-specific agility performance require rapid muscle contractions and therefore muscle fibre types [32]. Besides, speed and power have been widely considered as factors with a positive influence generic agility [15, 20, 27]. Although no systematic studies to predict the factors of influence on futsal specific agility performances and confirm such considerations, it is noteworthy that some authors examined correlations between physiological variables, and futsal-specific performances [26, 28]. In short, relatively poor associations between FS_COD and FS_RAG and various physiological variables, including speed and power, were evidenced.

However, it should be emphasized that aim of these studies was not investigate factors associated with futsal-specific agility performances (i.e., results and causes were not properly discussed), and that consequently true knowledge on this issue is limited. Even the authors itself highlighted the necessity of further research in this area because of their relatively simple methodological approach [26, 28]. Considering this research gap, more research is needed to identify predictors of futsal-specific performance and clarify this issue. The results of such research may provide detailed knowledge on factors that might influence real-game futsal situations, while improving match performance in this way will most likely contribute greatly to the achievement of greater overall success in futsal.

Given the theoretical background of relationship between speed/power and futsal-specific agility performance discussed previously, it seems reasonable to consider generic speed and power as predictors of futsal-specific CODS and RAG, as well as generic agility and anthropometrics which have been evidenced to influence futsal-specific agility performance [10, 14, 28, 30]. Therefore, this study aimed to evaluate the generic motor abilities and anthropometrics as predictors of futsal-specific CODS and RAG in professional male futsal players.

Materials and methods

Participants

Seventy-five professional male futsal players (age = 25.1 ± 5.1 years, body height = 182.3 ± 6.03 cm, body mass = 80.8 ± 11.6 kg) voluntarily participated in the study. All players were members of seven futsal teams that competed at the highest national level in Croatia and in Bosnia and Herzegovina. The participants were selected based on the following criteria: a minimum of 7 years of active involvement in futsal, older than 18 years of age, free from injury or illness, and regular performance of standard training for at least 3 weeks prior to testing.

All participants were regularly involved in futsal-specific training sessions to improve technical-tactical skills (10–12 h per week). In addition, the players participated for 2–3 h per week in strength and conditioning training sessions to improve their speed, strength, and power capacities. To ensure optimal physical condition on the testing day, participants were asked to refrain from any high-intensity activities; tobacco, alcohol, or caffeine use; or sleep deprivation for at least 2 days before the testing sessions.

The investigation was approved by the local university's ethics board (approval number: 2181-205-02-05-14-001), and all data were anonymized in accordance with the principles of the Declaration of Helsinki to ensure player and team confidentiality. All participants were informed of the purpose, benefits, and risks of the investigation, and all provided written consent for participation in the study.

Procedures

Testing was conducted over two days in September 2019 at the beginning of the competitive season. On the first testing day, body height (BH), body mass (BM), body fat percentage (BF%), countermovement jump (CMJ), standing broad jump (SBJ), reactive strength index (RSI), sprinting over 10 m (S10m), and the 20-yard generic CODS test (20-yards) were measured. On the second day, futsal-specific CODS and RAG tests were performed. All tests were performed in a sport hall on a parquet floor between 8:00 and 11:00 to minimize the influence of climatic and other conditions and to avoid diurnal variation. A standardized warm-up was performed before testing, which included (in the following order): 5 min of light jogging, 5 min of dynamic stretching exercises, and 5 min of high-intensity futsal-specific exercises (e.g., jumps, sprints, change of direction, etc.).

Variables

The independent variables (i.e., predictors) in this study included BH, BM, BF%, CMJ, SBJ, RSI, S10m, and 20-yards. The dependent variables were the futsal-specific change-of-direction speed test without dribbling ($FCODS_T$), futsal-specific change-of-direction speed test while dribbling the ball ($FCODS_D$), futsal-specific reactive agility test without dribbling on the dominant side ($FRAG_{TD}$), futsal-specific reactive agility test while dribbling the ball on the dominant side ($FRAG_{DD}$), futsal-specific reactive agility test without dribbling on the nondominant side ($FRAG_{TN}$), and futsal-specific reactive agility test while dribbling the ball on the nondominant side ($FRAG_{DN}$). The reliability of all variables was checked with the intra-class coefficient (ICC).

Anthropometrics

BH and BM were measured while barefoot by using Seca stadiometers and scales, respectively (Seca, Birmingham, UK). Skin callipers (Holtain, London, UK) were used to measure BF%. The BF% was calculated using the body density (BD) according to the following formula: $BD = 1.162 - 0.063 \cdot \log \Sigma 4SF$ (where Σ4SF = the sum of the biceps, triceps, subscapular, and suprailiac skinfolds). The body density was then converted into body fat percentage as follows: $BF\% = (4.95/BD - 4.5) \cdot 100.18$ [20].

Generic assessments

The CMJ was measured by using Optojump equipment (Microgate, Bolzano, Italy). The testing procedure included a maximum upward vertical jump after moving downward from an upright starting position with the hands placed on the hips [7]. The test's reliability was high (ICC: 0.80). The SBJ was evaluated with a measuring scale (ELAN, Begunje, Slovenia). Participants were instructed to vigorously jump forward as far as possible from a standing position. The length of the correct jump was recorded in centimetres from the line of reflection to the heel of the foot closest to the point of reflection [28]. The test's reliability was high (ICC: 0.88). The RSI was assessed by using Optojump equipment (Microgate, Bolzano, Italy). The participants were instructed to step off from a height and jump as far up as possible while attempting to minimize the contact time. The test's results were calculated by using the height jumped from the lower position and the time spent on the ground to develop the forces required for that jump [20]. The test's reliability was appropriate (ICC: 0.75). Each player performed three trials for each test with 30 s of rest between trials, and the best performance was used as the final result.

The S10m was measured with the Powertimer Newtest timing gate system (Oulu, Finland). Electronic timing gates were positioned at 1 m (beginning of the measurement) and 11 m from the starting line. The participants were instructed to begin with their preferred foot forward, which was placed on a starting line, and to run as quickly as possible distance from a stationary standing start. The time stopped after the participant passed the second gate [32]. Each player performed three trials with 2 min of rest between trials, and the best performance was used as the final result. The reliability for test was high (ICC: 0.93, respectively).

The 20-yards test was used to measure the generic CODS. The test was organised with one timing gate (Powertimer Newtest, Oulu, Finland) and three cones placed on the same line with 5 yards between them. The timing gate was positioned at the middle cone, and the starting position of the participants was 0.5 m to the right in a lateral stance. The test started when participants rotated their bodies to the left and triggered the time while passing the timing gate. The participants ran 5 yd to the left cone, performed a change of direction, then ran 10 yd to the opposite side, performed another change of direction, and ran 5 yd toward the middle cone. When the middle cone was reached, the time was stopped [28]. Each player performed three trials with 60 s of rest between trials, and the best performance was used as the final result. The test's reliability was high (ICC: 0.90).

Futsal-specific assessments

Futsal-specific CODS (FCODS) and RAG (FRAG) were assessed with recently developed Y-shaped tests that followed two procedures: (i) The participants had to touch the ball at the precise moment at which a change of direction occurred ($FCODS_T$, $FRAG_{TD}$, and $FRAG_{TN}$); (ii) the participants dribbled a ball during the execution of each test ($FCODS_D$, $FRAG_{DD}$, and $FRAG_{DN}$). The timing for the FRAG tests began when the participants crossed the initial infrared signal. At that moment, a hardware module lit one cone that was 30 cm high (A or B). As no prior indication was provided for the FRAG tests, the participants had to quickly notice the specific light and react accordingly. Thus, their RAG performance was unplanned. For the CODS tests, the participants had advance knowledge of which cone would light up and were, therefore, able to pre-plan their movements. The participants were instructed to perform maximally concentrated tests [25, 28].

For $FCODS_D$, $FRAG_{DD}$, and $FRAG_{DN}$, the participants were instructed to dribble a ball to a marked circle on the ground in front of the designated cone. The participants left the ball within the circle, and then changed their direction to run back to the starting line as quickly as possible (Fig. 1a). For $FCODS_T$, $FRAG_{TD}$, and $FRAG_{TN}$, the participants had to run to the ball, which was placed in front of the cone, touch it with the sole of the foot, and then run back through the infrared signal to stop the timer (Fig. 1b). The FRAG and FCODS tests were performed over five trials (with 1 min of rest between each trial) with either the known scenario (for $FCODS_T$ and $FCODS_D$) or the unknown scenario/template (for $FRAG_{DD}$, $FRAG_{DN}$, $FRAG_{TD,}$ and $FRAG_{TN}$). The FCODS and FRAG tests used in this study were recently studied for their reliability and validity, and the results were presented in detail elsewhere (ICC ranged from 0.77 to 0.80) [25, 28].

To determine the dominant and nondominant sides, the mean values for all B-cone performances (i.e., executions on the right side) and all A-cone performances (i.e., executions on the left side) for each participant and each executed test were calculated first. The performance side with the lower mean value was determined to be the dominant side for each executed test (for each individual player) [25].

The measurement of the CODS and RAG performance was carried out with a hardware device based on an ATMEL microcontroller (model AT89C51RE2; ATMEL Corp, San Jose, CA, United States). A photoelectric infrared sensor (E18-D80NK) served as an external time-triggering input, and light-emitting diodes were used as outputs. The photoelectric infrared sensor (see Figure 1—IR) had a response time of less than 2 ms and a digital output signal. The distance of the sensor for detection ranged from 3 to 80 cm, and it had the capability of detecting transparent objects. The sensor was connected with a microcontroller IO port (Figure 1 – IR). The device was connected to a PC running the Windows 7 operating system, as previously presented [20, 21, 25, 28].

Statistical analyses

Normality was confirmed using the Kolmogorov–Smirnov test, and means and standard deviations were calculated. Homoscedasticity was proven by the Levene test. All fitness tests were checked for intra-testing reliability by calculation of the intraclass correlation coefficient (ICC).

The univariate relationships were calculated using Pearson's correlation coefficients. The multivariate relationships among the predictors and the criteria (agility performance) were assessed with multiple regression analysis. As a preliminary phase, the predictors were checked for multicollinearity. The variance inflation (VIF) factor for the 10-yards test was 7.04, and therefore, this variable was not included in the multiple regressions. For all other variables, the VIF was less than 5.

In the first phase, multiple regressions for each criterion (i.e., $FCODS_T$, $FCODS_D$, $FRAG_{TD}$, $FRAG_{DD}$, $FRAG_{TN}$, and $FRAG_{DN}$) were calculated using half of the participants (n = 38; the randomly selected validation sample). The regression model equations were then applied to the remaining half of the participants (n = 37; the cross-validation sample). In the second phase, the actual performance

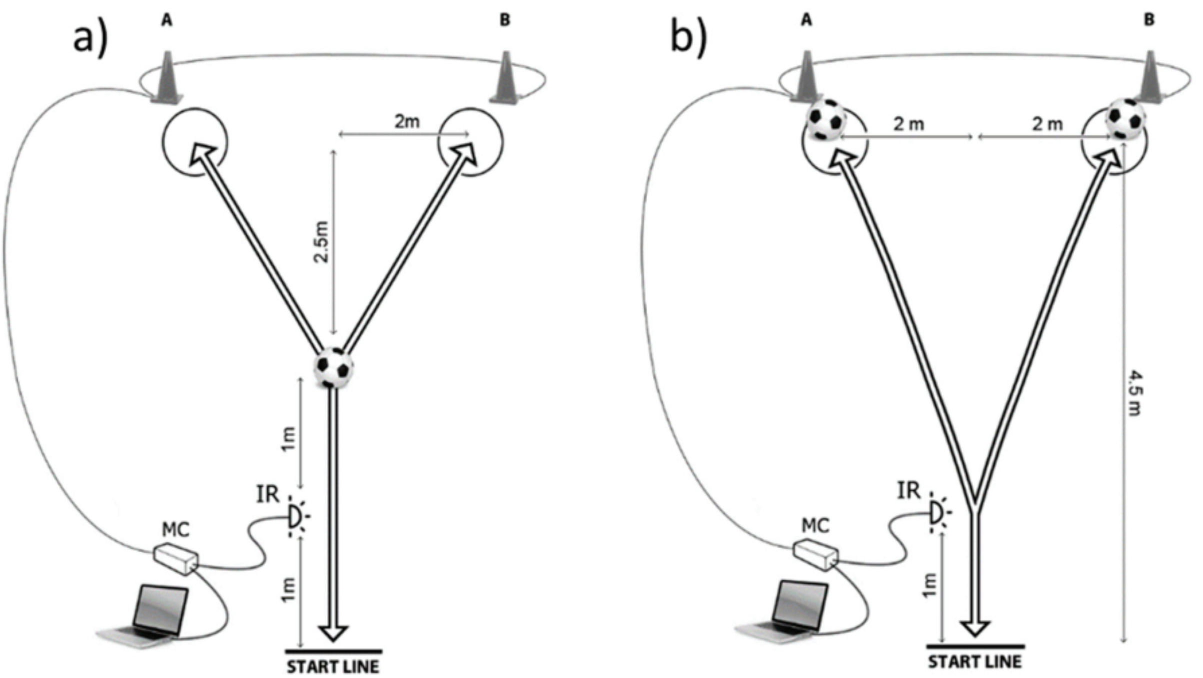

Figure 1. Testing of the futsal specific agility and change of direction speed with dribbling the ball (a), and without dribbling the ball (b)

scores of the cross-validation sample were then correlated to their predicted (calculated) performance scores. Afterwards, the calculated and achieved performance scores were compared by means of a t-test for dependent samples [20, 32].

Cohen's d was used to identify effect sizes (ES), and was interpreted as follows: trivial (<0.2), small (>0.2–0.5), moderate (>0.5–0.8) and large (>0.8) [6]. The 95% confidence intervals for ES were reported. Pearson's correlation coefficient was used to identify associations with the r coefficient classification as previously suggested: $r \leq 0.35$ indicates a low or weak correlation, r = 0.36 to 0.67 indicates a modest or moderate correlation, r = 0.68 to 0.1 indicates a strong or high correlation [33]. All statistical analyses were conducted using the SPSS software (IBM, SPSS, Version 25.0), and $p < 0.05$ was considered statistically significant.

Results

The players' achievements in $FCODS_T$ were 15% (d (95% confidence interval) = –1.43 (–1.78, –1.07), large ES) and 27% (d = –2.34 (–2.74, –1.91), large ES) better than their achievements in $FRAG_{TD}$ and $FRAG_{TN}$.

In addition, the players' achievements in $FCODS_D$ were 2% (d = –0.16 (–0.48, 0.16), small ES) and 7% (d = –0.67 (–0.99, –0.33), moderate ES) better than their achievements in $FRAG_{DD}$ and $FRAG_{DN}$.

The players achieved 9% (d = –0.86 (–1.19, –0.52), large ES) better results in $FRAG_{TD}$ than in $FRAG_{TN}$, while the players' average achievement in $FRAG_{DD}$ was 6% (d = –0.53 (–0.85, –0.20), moderate ES) better than in $FRAG_{DN}$.

CMJ was significantly associated with $FRAG_{TN}$ (small correlation; 7% of common variance). The reactive strength index was positively correlated with $FCODS^T$ and $FRAG_{DN}$ (both small correlations; 5–10% of common variance). SBJ was significantly correlated with $FCODS_T$, $FCODS_D$, $FRAG_{TD}$, and $FRAG_{TN}$ (all small correlations; 6–8% common variance). S10m was not correlated with any agility performances. In contrast, the 20-yards test was significantly associated with all types of agility performance (all moderate correlations; 14–26% of common variance). BW and BF% were significantly correlated with $FCODS_T$, $FCODS_D$, $FRAG_{TD}$, and $FRAG_{TN}$ (small to moderate correlations; 7–16% of common variance) (Table 2).

Table 3 presents correlations between predictors variables. All correlations were logical and expected (i.e.,

Table 1. Descriptive and reliability parameter of studied variables

	Mean ± SD	Minimum	Maximum	ICC
Agility performances				
$FCODS_T$ [s]	2.11 ± 0.19	1.76	2.75	0.79
$FCODS_D$ [s]	2.50 ± 0.26	2.04	3.24	0.78
$FRAG_{TD}$ [s]	2.42 ± 0.24	2.03	3.18	0.77
$FRAG_{DD}$ [s]	2.54 ± 0.25	2.20	3.29	0.77
$FRAG_{TN}$ [s]	2.63 ± 0.25	2.20	3.51	0.78
$FRAG_{DN}$ [s]	2.68 ± 0.28	2.20	3.54	0.80
Motor abilities				
CMJ [cm]	38.61 ± 5.11	24.50	51.30	0.80
RSI [index]	145.97 ± 37.45	62.24	242.76	0.75
SBJ [cm]	238.89 ± 20.26	195.00	279.00	0.88
Sprint 10 m [s]	1.71 ± 0.11	1.53	1.98	0.93
20-yards [s]	4.65 ± 0.26	4.14	5.40	0.90
Anthropometrics				
Body height [cm]	182.42 ± 6.03	168.00	197.50	
Body weight [kg]	80.88 ± 11.57	56.50	139.90	
Body fat [%]	9.15 ± 3.67	2.99	22.25	

SD – standard deviation, ICC – intraclass coefficient.

Table 2. Pearson's correlation coefficients between futsal specific CODS and RAG performance and predictor variables

	$FCODS_T$	$FCODS_D$	$FRAG_{TD}$	$FRAG_{DD}$	$FRAG_{TN}$	$FRAG_{DN}$
Body height	0.14	0.16	0.06	–0.02	0.07	0.03
Body weight	0.29*	0.40***	0.27*	0.20	0.32**	0.22
Body fat %	0.33**	0.33**	0.34**	0.22	0.38**	0.22
CMJ	–0.21	–0.21	–0.22	–0.12	–0.26*	–0.14
RSI	–0.31**	–0.21	–0.22	–0.21	–0.21	–0.23*
SBJ	–0.24*	–0.26*	–0.28*	–0.22	–0.29*	–0.21
Sprint 10 m	0.09	0.13	0.12	0.11	0.17	0.08
20-yards	0.43***	0.51***	0.42***	0.40***	0.37***	0.43***

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Table 3. Pearson's correlation coefficients between predictor variables

	BH	BW	BF%	CMJ	RSI	SBJ	S10m
BW	0.58***						
Body fat %	0.22	0.71***					
CMJ	–0.14	–0.26*	–0.29*				
RSI	–0.12	–0.21	–0.32**	0.36**			
SBJ	0.05	–0.20	–0.46***	0.63***	0.37**		
S10m	0.14	0.33**	0.38**	–0.40**	–0.25*	–0.42***	
20-yards	0.05	0.46***	0.63***	–0.39**	–0.46***	–0.46***	0.40***

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

correlations between body fat and motor abilities, correlation between jumping capacities, etc), while all values of correlations were small to moderate (maximum 50% common variance or less).

When multiple regressions were calculated for $FCODS_T$ and $FCODS_D$ in the validation subsample of the participants, the predictors explained 54% and 56% of the variance of the criteria, with 20-yards being significantly partially associated with both criteria. For $FRAG_{TD}$ and $FRAG_{DD}$ in the validation subsample of the participants, the predictors explained 52% and 39% of the variance of the criteria, with 20-yards being significantly partially associated with $FRAG_{TD}$. On the other hand, for $FRAG_{TN}$ and $FRAG_{DN}$ in the validation subsample of the participants, the predictors explained 40% and 61% of the variance of the criteria, with 20-yards and BH being significantly partially associated with $FRAG_{DN}$ (Table 4).

The established regression models were then applied to the cross-validation subsample of the participants:

$FCODS_T = –0.4755 + 0.00142 \cdot BH + 0.003408 \cdot BW + 0.003428 \cdot BF\% + 0.002173 \cdot CMJ + 0.000272 \cdot RSI + 0.001351 \cdot SBJ – 0.1502 \cdot S10m + 0.4424 \cdot 20\text{-yards}$

$FCODS_D = 0.9030 + 0.001147 \cdot BH + 0.006756 \cdot BW – 0.01551 \cdot BF\% + 0.000480 \cdot CMJ + 0.000922 \cdot RSI + 0.002462 \cdot SBJ – 0.6983 \cdot S10m + 0.640417 \cdot 20\text{-yards}$

$FRAG_{TD} = 0.1474 – 0.007565 \cdot BH + 0.008480 \cdot BW + 0.000911 \cdot BF\% + 0.006808 \cdot CMJ – 0.000791 \cdot RSI + 0.002374 \cdot SBJ – 0.2278 \cdot S10m + 0.5578 \cdot 20\text{-yards}$

$FRAG_{DD} = 0.4425 – 0.008702 \cdot BH + 0.008429 \cdot BW – 0.01691 \cdot BF\% + 0.01252 \cdot CMJ – 0.000985 \cdot RSI – 0.000303 \cdot SBJ + 0.3286 \cdot S10m + 0.5121 \cdot 20\text{-yards}$

$FRAG_{TN} = 1.285 – 0.01027 \cdot BH + 0.009511 \cdot BW + 0.005797 \cdot BF\% + 0.002419 \cdot CMJ – 0.001101 \cdot RSI + 0.003214 \cdot SBJ + 0.041573 \cdot S10m + 0.330193 \cdot 20\text{-yards}$

$FRAG_{DN} = –0.1767 – 0.01297 \cdot BH + 0.01541 \cdot BW – 0.03181 \cdot BF\% + 0.01383 \cdot CMJ – 0.001315 \cdot RSI + 0.007758 \cdot SBJ + 0.1163 \cdot S10m + 0.7527 \cdot 20\text{-yards}$

The correlations between the calculated and observed scores for the cross-validation subsample were 0.05, 0.26,

Table 4. Multiple regression of futsal specific CODS and RAG performance calculated for validation sample of participants (data are given as non-standardized regression coefficients)

	$FCODS_T$	$FCODS_D$	$FRAG_{TD}$	$FRAG_{DD}$	$FRAG_{TN}$	$FRAG_{DN}$
Intercept	–0.48	0.90	0.15	0.44	1.29	–0.18
Body height	0.00	0.00	–0.01	–0.01	–0.01	–0.01
Body weight	0.00	0.01	0.01	0.01	0.01	0.02*
Body fat %	0.00	–0.01	0.00	–0.02	0.01	–0.03
CMJ	0.00	0.00	0.01	0.01	0.00	0.01
RSI	0.00	0.00	0.00	0.00	0.00	0.00
SBJ	0.00	0.00	0.00	0.00	0.00	0.00
Sprint 10 m	–0.15	–0.70	–0.23	0.33	0.04	0.12
20-yards	0.44	0.64*	0.56*	0.51*	0.33	0.75*
R	0.73	0.75	0.72	0.63	0.64	0.78
R^2	0.54	0.56	0.52	0.39	0.40	0.61
p	0.01	0.01	0.01	0.06	0.04	0.01

R – multiple correlation; R^2 – coefficient of determination; * denotes statistical significance of $p < 0.05$.

–0.05, 0.06, –0.05, and –0.06 for $FCODS_T$, $FCODS_D$, $FRAG_{TD}$, $FRAG_{DD}$, $FRAG_{TN}$, and $FRAG_{DN}$, respectively (all $p > 0.05$). In the next phase, the calculated and observed scores for the cross-validation subsample were compared by means of a T-test for dependent samples. Significant differences between the calculated and observed scores were found for all agility performances (t-values from 6.30 to 27.09, all $p < 0.001$). Accordingly, we may emphasise the inappropriateness of the regression modelling for all types of agility performance.

Discussion

This study is one of the first to systematically evaluate the predictors of futsal-specific CODS and RAG performance in professional male futsal players. Generic speed, power, and agility capabilities, as well as anthropometrics, were poorly correlated with futsal-specific CODS and RAG performance. In addition, multiple regression modelling with running speed, power, agility, and anthropometric/body-built indices as predictors did not allow the determination of valid regression models for the definition of futsal-specific CODS and RAG performance. These findings clearly indicate that the predictors studied here are not valid for predicting futsal-specific CODS and RAG performance among professional futsal players.

Due to the similarity in physiological backgrounds of agility, power, and speed performance (i.e., all three types of performance require the intensive involvement of fast-twitch muscle fibres), it is considered that increased speed and power capabilities may result in better generic agility performance [10, 14, 29, 30]. Moreover, previous research showed that even sport-specific agility performance may be, to some extent, influenced by power capacity [20]. In particular, Pehar et al. demonstrated that the broad jump is an important predictor of basketball-specific CODS, while the reactive strength index is directly related to basketball-specific CODS and RAG performance. However, the results from our study do not support such conclusions for futsal players. Specifically, the multiple regression models established in our study were not successfully cross-validated for $FCODS_T$, $FCODS_D$, $FRAG_{TD}$, $FRAG_{DD}$, $FRAG_{TN}$, and $FRAG_{DN}$. These findings show that generic speed and power capabilities, together with anthropometrics (e.g., body weight, height, and fat) and generic agility performance, are not decisive in defining futsal-specific CODS and RAG performance.

Considering that optimal agility is manifested differently across various sports – for example, basketball, tennis, and handball involve significant "stop-and-go" transitions, while football and rugby primarily involve rapid directional changes [29] – it is not surprising that the results differ when observing the agility performance of players of different sports. Moreover, basketball-specific agility tests consist of manipulating the ball with the upper limbs, while futsal-specific agility tests involve manipulating the ball with the lower limbs. This most likely results in different biomechanics when performing directional changes, which consequently place different demands on players' physical capacities. In addition, the aforementioned study included basketball players from the second division, while we observed only first-division futsal players [20].

Specifically, cognitive and perceptual factors play an important role in achieving better agility performance, and research has indicated that lower-level athletes generally have weaker cognitive capabilities and technical performance than higher-level athletes [19, 23, 24]. Lower-level athletes (e.g., basketball players in the study of Pehar et al.) possibly compensate for their cognitive capabilities and technical performance with physical factors, which consequently promote their motor abilities and anthropometrics as important predictors of agility performance [20]. On the other hand, some of the futsal players studied here were the winners of national championships and participants in the Futsal Champions League of the Union of European Football Association (UEFA) (which is the highest competition level for futsal teams in Europe). Such top-level players may have superior cognitive and perceptual capabilities, as well as technical performance, which almost certainly decreases the direct influence of physical capacities on the execution of agility tasks. As a consequence, their motor abilities and anthropometrics most likely appeared to be non-valid predictors of agility performance. However, considering that this investigation did not analyse cognitive and technical capabilities, these speculations should be confirmed in future studies.

The results of regression modelling suggesting that motor abilities and anthropometrics are non-valid predictors of futsal-specific agility performance can be directly supported by analysing the univariate correlations between predictors and criteria. Specifically, although CMJ, RSI, SBJ, 20-yards, BW, and BF% were significantly correlated with the different facets of agility ($r = 0.23–0.51$; all small to moderate correlations), the common variances ranged from 5% to a maximum of 26%. In addition, S10m and BH were not at all significantly correlated with the criteria. These results clearly indicate that generic power, speed, and agility capacities, as well as anthropometrics, are poorly related to futsal-specific CODS and RAG performance. These findings are in the line with those of previous research that correlated various physiological and anthropometric variables with futsal-specific CODS and RAG performance and reported poor associations between them [26, 28].

The present investigation has some limitations that should be considered. Firstly, this is a cross-sectional study, and therefore, for a more thorough analysis of the predictors of futsal-specific agility performance, longitudinal analyses are needed. In addition, a limited number of independent variables were included to assess generic power, speed, and agility, which could have affected the results. To provide more a comprehensive understanding of the predictors of futsal-specific CODS and RAG performance, future research should evaluate other factors that may influence futsal-specific agility performance, such as cognitive and perceptual factors and technical performance. In addition, other types of agility performance (e.g., stop-and-go agility) should be considered. Finally, observing players according to their playing positions may contribute to a better applicability of the results.

Conclusion

This study showed that futsal-specific CODS and RAG performance is poorly related to the generic power, speed, agility, and anthropometrics, indicating that players' motor abilities and anthropometric characteristics are not decisive in defining futsal-specific agility performance. Considering that the agility performance studied here mimics real-game situations in futsal, the findings from this study demonstrate that superiority in generic power and speed, as well as in generic agility performance and anthropometrics, may not have a significant effect on futsal match performance. On the other hand, it is most likely that superior cognitive and perceptual factors, such as response time and decision-making time, together with superior technical performance, may greatly contribute to the achievement of successful match performance in futsal matches. Therefore, training protocols that aim to develop or maintain motor abilities should be specific to futsal (i.e., match-related). This most specifically means that the implementation of a ball and the stimulation of cognitive and perceptual capabilities are highly recommended for the conditioning of futsal players. Such a training approach may have a positive impact on futsal match performance and, consequently, on the performance of the whole team.

Conflict of interest: Authors state no conflict of interest.

References

1. Ayarra R., Nakamura F.Y., Iturricastillo A., Castillo D., Yanci J. (2018) Differences in physical performance according to the competitive level in futsal players. *J. Hum. Kinet.*, 64: 275-285.
2. Barbero-Alvarez J., Soto V., Barbero-Alvarez V., Granda-Vera J. (2008) Match analysis and heart rate of futsal players during competition. *J. Sports Sci.*, 26: 63-73.
3. Bartolomei S., Nigro F., Gubellini L., Ciacci S., Merni F., Treno F., Cortesi M., Semprini G. (2019) Physiological and Sport-Specific Comparison Between Division I and Division II Italian Male Field Hockey Players. *J. Strength Cond. Res.*, 33: 3123-3128.

4. Bjelica D., Milosevic Z., Talovic M., Bajramovic I. (2018) Repulsion of the futsal ball depending on the pressure in it. *Sport Mont*, 16: 61-67.
5. Castagna C., D'Ottavio S., Vera J.G., Álvarez J.C.B. (2009) Match demands of professional Futsal: a case study. *J. Sci. Med. Sport*, 12: 490-494.
6. Cohen J. (2013) *Statistical power analysis for the behavioral sciences*. Academic press.
7. Della Corte J., Pereira W.L.M., Corrêa E.E.L.S., de Oliveira J.G.M., Lima B.L.P., de Castro J.B.P., Lima V.P. (2020) Influence of power and maximal strength training on thermal reaction and vertical jump performance in Brazilian basketball players: A preliminary study. *Biomed. Hum. Kinet.*, 12: 91-100.
8. Farhani F., Rajabi H., Negaresh R., Ali A., Amani Shalamzari S., Baker J.S. (2019) Reliability and Validity of a Novel Futsal Special Performance Test Designed to Measure Skills and Anaerobic Performance. *Int. J. Sports Physiol. Perform.*, 14: 1096-1102.
9. Fiorilli G., Mitrotasios M., Iuliano E., Pistone E.M., Aquino G., Calcagno G. (2016) Agility and change of direction in soccer: differences according to the player ages. *J. Sports Med. Phys. Fitness*, 57: 1597-1604.
10. Gabbett T.J., Kelly J.N., Sheppard J.M. (2008) Speed, change of direction speed, and reactive agility of rugby league players. *J. Strength Cond. Res.*, 22: 174-181.
11. Hulka K., Weisser R. (2017) The influence of the number of players on workload during small-sided games among elite futsal players. *Montenegrin J. Sports Sci. Med.*, 6: 45-48.
12. Krolo A., Gilic B., Foretic N., Pojskic H., Hammami R., Spasic M., Uljevic O., Versic S., Sekulic D. (2020) Agility Testing in Youth Football (Soccer) Players; Evaluating Reliability, Validity, and Correlates of Newly Developed Testing Protocols. *Int. J. Environ Res. Public Health*, 17: 294.
13. Kutlu M., Yapıcı H., Yoncalık O., Celik S. (2012) Comparison of a new test for agility and skill in soccer with other agility tests. *J. Hum. Kinet.*, 33: 143-50.
14. Marković G., Sekulić D., Marković M. (2007) Is agility related to strength qualities? – Analysis in latent space. *Coll. Antropol.*, 31: 787-793.
15. Mijatovic D., Krivokapic D., Versic S., Dimitric G., Zenic N. (2022) Change of Direction Speed and Reactive Agility in Prediction of Injury in Football; Prospective Analysis over One Half-Season. *Healthcare*, 10: 440.
16. Nakamura F.Y., Pereira L.A., Cal Abad C.C., Kobal R., Kitamura K., Roschel H., Rabelo F., Souza W.A., Loturco I. (2016) Differences in physical performance between U-20 and senior top-level Brazilian futsal players. *J. Sports Med. Phys. Fitness*, 56: 1289-1297.
17. Naser N., Ali A. (2016) A descriptive-comparative study of performance characteristics in futsal players of different levels. *J. Sports Sci.*, 34: 1707-1715.
18. Naser N., Ali A., Macadam P. (2017) Physical and physiological demands of futsal. *J. Exerc. Sci. Fit.*, 15: 76-80.
19. Paul D.J., Gabbett T.J., Nassis G.P. (2016) Agility in team sports: Testing, training and factors affecting performance. *Sports Med.*, 46: 421-442.
20. Pehar M., Sisic N., Sekulic D., Coh M., Uljevic O., Spasic M., Krolo A., Idrizovic K. (2018) Analyzing the relationship between anthropometric and motor indices with basketball specific pre-planned and non-planned agility performances. *J. Sports Med. Phys. Fitness*, 58: 1037-1044.
21. Pojskic H., Åslin E., Krolo A., Jukic I., Uljevic O., Spasic M., Sekulic D. (2018) 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.*, 9: 506. DOI: 10.3389/fphys.2018.00506.
22. Ramos-Campo D.J., Rubio-Arias J., Carrasco-Poyatos M., Alcaraz P. (2016) Physical performance of elite and subelite Spanish female futsal players. *Biol. Sport*, 33: 297.
23. Santos J., Mendez-Domínguez C., Nunes C., Gómez M.A., Travassos B. (2020) Examining the key performance indicators of all-star players and winning teams in elite futsal. *Int. J. Perform. Anal. Sport*, 20: 78-89.
24. Scharfen H.E., Memmert D. (2019) Measurement of cognitive functions in experts and elite athletes: A meta-analytic review. *Appl. Cogn. Psychol.*, 33: 843-860.
25. Sekulic D., Foretic N., Gilic B., Esco M.R., Hammami R., Uljevic O., Versic S., Spasic M. (2019) Importance of agility performance in professional futsal players; Reliability and applicability of newly developed testing protocols. *Int. J. Environ. Res. Public Health*, 16: 3246.
26. Sekulic D., Gilic B., Foretic N., Spasic M., Uljević O., Veršić Š. (2020) Fitness profiles of professional futsal players: identifying age-related differences. *Biomed. Hum. Kinet.*, 12: 212. DOI: 10.2478/bhk-2020-0027.
27. Sekulic D., Pehar M., Krolo A., Spasic M., Uljevic O., Calleja-González J., Sattler T. (2017) Evaluation of basketball-specific agility: applicability of preplanned and nonplanned agility performances for differentiating playing positions and playing levels. *J. Strength Cond. Res.*, 31: 2278-2288.
28. Sekulic D., Pojskic H., Zeljko I., Pehar M., Modric T., Versic S., Novak D. (2021) Physiological and Anthropometric Determinants of Performance Levels in Professional Futsal. *Front. Psychol.*, 11: DOI: 10.3389/fpsyg.2020.621763.
29. Sekulic D., Spasic M., Esco M.R. (2014) Predicting agility performance with other performance variables in pubescent boys: a multiple-regression approach. *Percept. Mot. Skills.*, 118: 447-461.
30. Sekulic D., Spasic M., Mirkov D., Cavar M., Sattler T. (2013) Gender-specific influences of balance, speed, and

power on agility performance. *J. Strength Cond. Res.*, 27: 802-811.
31. Sheppard J.M., Young W.B. (2006) Agility literature review: Classifications, training and testing. *J. Sports Sci.*, 24: 919-932.
32. Spasic M., Uljevic O., Coh M., Dzelalija M., Sekulic D. (2013) Predictors of agility performance among early pubescent girls. *Int. J. Perform. Anal. Sport*, 13: 480-499.
33. Taylor R. (1990) Interpretation of the correlation coefficient: a basic review. *J. Diagn. Med. Sonogr.*, 6: 35-39.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.