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Associations between reaction time, explosive strength, and agility in university athletes

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ABSTRACT

This study aimed to examine the relationships among explosive strength, agility, and reaction time in athletes enrolled at the School of Physical Education and Sports. In this context, the participants' explosive strength, reaction time, and agility parameters were measured using standardized protocols. The study sample consisted of 120 active athletes (68 males and 52 females), aged between 18 and 30, who were studying at Bartın University Faculty of Sports. All participants were actively engaged in various sports disciplines, participated in competitions, and trained in their respective branches at least three times per week. Based on the findings, a statistically significant moderate negative correlation was found between agility and reaction time in male athletes ($r = –.262$, $p < 0.05$), a strong negative correlation between explosive strength and agility ($r = –.595$, $p < 0.01$), and a moderate negative correlation between reaction time and explosive strength ($r = –.520$ to $–.594$, $p < 0.05$). In female athletes, a statistically significant strong positive correlation was observed between agility and reaction time, as well as between agility and explosive strength ($r = .354$, $p < 0.01$). These findings suggest that agility is closely linked to both reaction time and explosive strength, especially among female athletes, and highlight the need for integrated training approaches.

KEYWORDS

Athlete; Reaction Time; Explosive Force; Agility; Relationship

1. INTRODUCTION

The concept of performance in sports has been examined across multiple dimensions, with particular emphasis on motor skills such as reaction time, movement speed, and agility—each contributing significantly to athletic success. These attributes are widely recognized as components of fitness-related motor skills and are essential for executing rapid and efficient movements in competitive environments.

Reaction time is defined as the interval between the presentation of a stimulus and the initiation of a voluntary response. According to Merkel's model (1885), stimulus processing involves three stages: perception, decision-making, and response programming. As one of the earliest diagnostic tools in modern psychology, reaction time has been studied since the 19th century (Merkel, 1885).

Maximum running speed refers to the highest velocity an individual can attain, whereas agility lacks a universally accepted definition. It is generally described as "the rapid movement of the whole body with a change in speed or direction in response to a stimulus" (Gambetta, 1996; Sheppard & Young, 2006). This study focuses on reactive agility, which encompasses not only physical components such as strength, endurance, and technique, but also perceptual and cognitive elements including decision-making and stimulus recognition (Sheppard & Young, 2006).

Motor skills manifest at varying levels depending on the nature of the activity and interact in complex, coordinated ways. Each skill is further shaped by its sub-components (Bompa, 1998). Although reaction time, agility, and explosive strength may appear similar, they represent distinct physical capacities (Young et al., 2001).

Reaction time is considered a foundational element for both vertical jump performance and agility (Yildirim et al., 2010). Previous research has shown that training interventions can positively influence vertical jump height, reaction time, and agility (Kotzamanidis, 2003; Sheppard & Young, 2006). However, the interrelationships among these parameters remain underexplored in the literature.

It has been suggested that variables such as reaction time, vertical jump performance, agility, and body composition significantly contribute to athletic success across various sport disciplines. Understanding how these motor parameters interact may offer valuable insights for performance optimization and individualized training strategies.

In this context, the present study aims to investigate the associations between explosive strength, agility, and reaction time in undergraduate students enrolled in the Faculty of Sports Sciences. A descriptive-correlational research design was employed to examine the interrelationships among these key motor performance parameters. To guide the analysis, the following research questions were formulated:

- H1:Is there a significant relationship between reaction time and agility?
- H2: Does explosive strength predict agility performance?
- H3: Are there gender-based differences in the correlations among motor parameters

2. METHODS

2.1. Study Design and Participants

A quantitative research approach was adopted, as the data obtained through standardized measurement tools were numerical, objective, and reproducible. Specifically, a descriptive-correlational research design was employed to examine the relationships among key motor performance parameters agility, reaction time, and explosive strength without any experimental manipulation. The study aimed to identify associations across different sport disciplines and gender groups.

The study sample consisted of 120 athletes (68 male, 52 female) actively engaged in competitive sports across various disciplines. All participants were enrolled in the Faculty of Sports Sciences at Bartın University and had a minimum of three years of structured training experience. Inclusion criteria required regular participation in training sessions (≥3 times per week) and involvement in official competitions. The sample accurately represents the target population defined within the scope of the study.

2.2. Data Collection Tools and Procedure

The data collection techniques and instruments used are appropriate for achieving the research objectives. Participants refrained from maximal physical exertion immediately before and during testing and arrived in a rested state. Athletes performed each test with maximal effort under standardized conditions. Environmental factors (e.g., temperature, lighting, surface) remained consistent throughout the testing sessions and did not influence performance outcomes.

2.2.1. Body weight and height measurement

Body weight was measured using a Seca 769 digital scale with a precision of 0.01 kg. Height was recorded using a calibrated stadiometer during deep inspiration, following standardized postural alignment protocols (Ergün & Erten, 2004). These measurements were used to control for body composition variables that may influence motor performance outcomes, see Figure 1.

Figure 1. Seca 769 Height Gauge Scale

2.2.2. Agility

Agility was assessed using the Semenick-modified T-Test protocol, which evaluates multidirectional movement efficiency and change-of-direction speed. Cone placements followed biomechanical standards (10 m forward, 5 m lateral), and timing was recorded via the Newtest Powertimer 300 system to ensure temporal precision (Pauole et al., 2000; Gabbett & Georgieff, 2007). (See Figure 2)

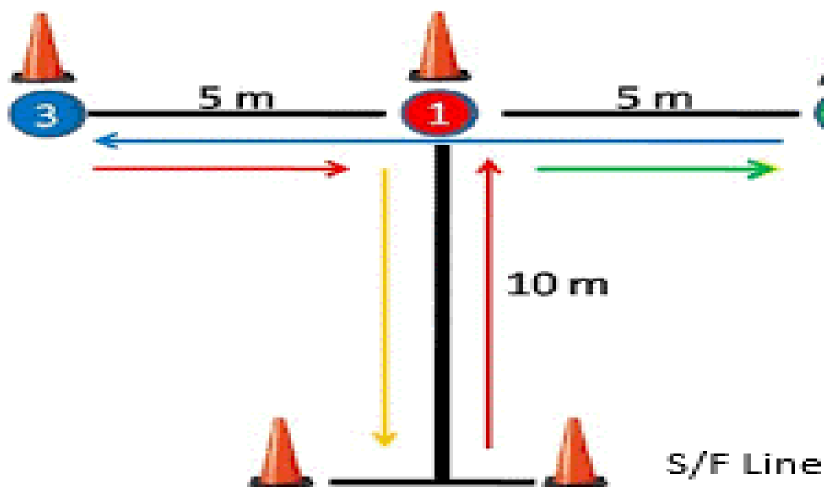

Figure 2. T Agility Test

2.2.3. Reaction time

Reaction time was measured using the Newtest 1000 device, which delivers randomized visual and auditory stimuli to minimize anticipatory bias. Each participant completed ten trials per stimulus type. Outliers were excluded using ±2 standard deviation thresholds to enhance internal validity (Tamer, 2000), see Figure 3.

Figure 3. Newtest 1000 Tool

2.2.4. Explosive strength

Explosive strength was evaluated via vertical jump height using the Takei-brand jump meter. Participants performed squat jumps with hands placed on hips to eliminate upper-body momentum. The best of three trials was recorded, and the device's precision ensured accurate quantification of lower-body power output (Harman et al., 1990; Alemdaroğlu, 2012) (Figure 4).

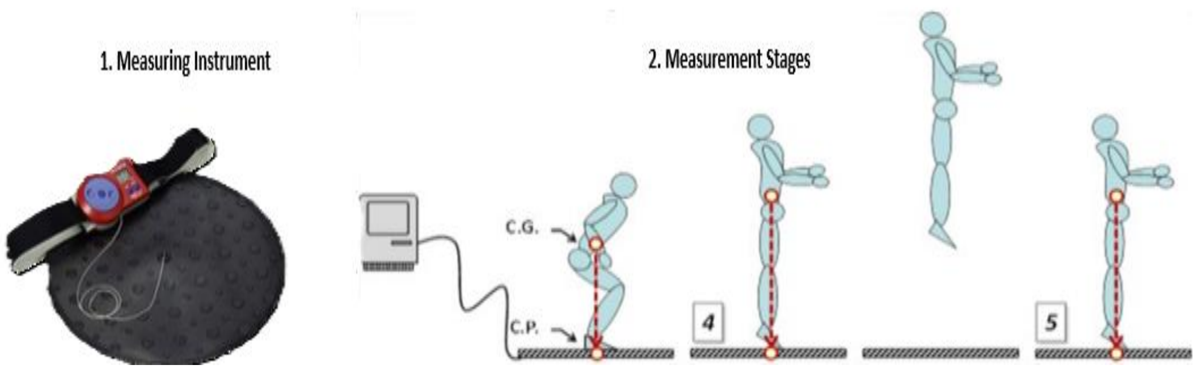

Figure 4. Vertical Jump Test

2.3. Statistical Analyses

All statistical analyses were performed using SPSS version 25.0. To assess the normality of the data distribution, the Kolmogorov-Smirnov test was applied. The results confirmed that the data were normally distributed, allowing for the use of parametric tests.

Pearson correlation analysis was conducted to examine the relationships among agility, reaction time, and explosive strength. Effect sizes were calculated using Cohen's d and interpreted as small (0.2), medium (0.5), and large (0.8). Statistical significance was reported in APA format, with thresholds of $p < .05$ and $p < .01$ clearly indicated.

3. RESULTS

Table 1 presents the descriptive characteristics of the study participants by sport and gender.

Table 1. Descriptive characteristics of participants

Branch	Gender	N	Age (years)	Sports Age (years)	Height (cm)	Body Weight (kg)
Karate	Male	8	21.00±1.85	7.00±1.85	179.75±4.92	76.25±8.36
	Female	3	21.33±1.24	3.33±0.47	167.00±3.74	50.40±1.17
Athletics	Male	10	20.00±0.63	3.60±1.20	173.60±2.49	69.72±5.22
	Female	9	19.44±1.94	4.00±0.66	162.66±3.09	48.93±1.60
Handball	Male	4	19.50±0.50	6.50±1.50	177.50±8.50	85.00±20.00
	Female	4	21.50±1.50	3.50±2.50	163.00±5.00	57.50±4.50
Barbell	Male	7	20.57±0.90	3.74±1.66	176.30±7.70	74.00±7.38
	Female	11	19.91±1.08	3.63±1.06	165.90±10.61	60.51±4.81
Badminton	Male	4	20.50±1.50	4.25±1.29	173.00±3.53	69.80±6.33
	Female	4	22.00±0.50	4.00±0.50	159.00±1.25	65.00±5.20
Volleyball	Male	9	19.89±1.05	6.44±1.58	180.40±5.19	69.56±2.87
	Female	4	20.50±0.57	6.50±0.59	172.00±2.88	57.00±9.23
Taekwondo	Male	4	20.75±1.63	4.75±1.78	176.00±6.28	71.30±5.42
	Female	6	19.50±0.76	6.33±2.35	160.50±6.42	56.20±4.04
Wrestling	Male	15	20.53±1.25	5.73±1.84	177.50±5.37	71.60±10.20
	Female	6	19.33±1.97	5.50±1.50	154.33±3.39	66.11±3.63
Basketball	Male	7	20.28±0.45	5.42±1.59	180.28±4.29	71.14±6.95
	Female	5	20.60±2.24	6.60±1.49	160.00±6.41	64.18±5.05
SUM	Male	68	20.35±1.20	5.32±1.99	177.38±5.87	72.46±9.36
	Female	52	20.19±1.71	4.73±1.87	162.19±7.23	58.26±7.23

In Table 1, the mean age of the male athletes (n = 68) was 20.35 ± 1.20 years, with an average sports experience of 5.32 ± 1.99 years. Their mean height was 177.38 ± 5.87 cm and mean body weight was 72.46 ± 9.36 kg. Female athletes (n = 52) had a mean age of 20.19 ± 1.71 years, sports experience of 4.73 ± 1.87 years, mean height of 162.19 ± 7.23 cm, and mean body weight of 58.26 ± 7.23 kg. In addition to statistical significance testing, effect size values (Cohen's d) were calculated to assess the practical magnitude of gender-based differences across motor performance parameters. These values are presented in Table 2.

Table 2. Effect Sizes (Cohen's d) for gender-based differences in motor performance parameters

Performance Variable	Male (Mean ± SD)	Female (Mean ± SD)	Cohen's d (r)	Effect Size Interpretation
Agility (s)	11.57 ± 1.07	12.95 ± 1.37	1.12	Large
Reaction Time (ms)	407.82 ± 83.38	428.11 ± 53.54	0.28	Small
Explosive Strength (cm)	54.94 ± 10.03	38.80 ± 8.84	1.71	Very Large

As shown in Table 2, the largest effect size was observed in explosive strength (Cohen's d = 1.71), indicating a very large practical difference favoring male participants. Agility also demonstrated a large effect (Cohen's d = 1.12), while reaction time differences yielded a small effect size (Cohen's d = 0.28), suggesting limited practical significance despite statistical significance. Table 3 presents the mean and standard deviation values for agility (seconds), reaction time (milliseconds), and explosive strength (centimeters) across different sport disciplines.

Table 3. Agility, reaction time, and explosive strength values of athletes by sport branch and gender

Branch	Gender	N	Agility (sn)	Reaction time (ms)	Explosive strength (cm)
Karate	**Male**	8	10.63±0.52	388.50±94.38	64.50±8.05
	Female	3	13.08±0.60	413.00±21.11	36.00±4.96
Athletics	**Male**	10	11.45±0.61	457.80±62.07	55.60±4.22
	Female	9	13.23±0.32	392.44±8.77	34.00±3.23
Handball	**Male**	4	10.99±0.20	373.50±17.50	52.50±1.50
	Female	4	11.65±1.14	521.50±93.50	35.50±0.50
Barbell	**Male**	7	12.45±1.05	372.30±36.91	45.71±6.64
	Female	11	12.57±1.08	423.80±45.42	47.09±9.48
Badminton	**Male**	4	11.29±1.07	358.00±3.67	43.75±8.92
	Female	4	12.93±0.90	469.00±47.55	31.00±6.78
Volleyball	**Male**	9	12.09±1.29	403.30±64.46	55.78±12.23
	Female	4	13.22±1.29	425.50±52.53	39.00±4.61
Taekwondo	**Male**	4	11.98±1.13	358.50±3.35	48.25±7.85
	Female	6	12.19±0.72	426.16±9.59	35.33±3.44
Wrestling	**Male**	15	11.56±1.03	455.20±108.50	59.07±8.81
	Female	6	13.63±2.56	447.16±37.03	42.00±12.04
Basketball	**Male**	7	11.54±1.09	374.57±83.13	54.00±9.75
	Female	5	14.12±1.22	385.00±37.14	40.00±9.85
SUM	**Male**	68	11.57±1.07	407.82±83.38	54.94±10.03
	Female	52	12.95±1.37	428.11±53.54	38.80±8.84

Data are stratified by gender to highlight performance differences. Agility was assessed using the T-Test protocol, reaction time was measured using the Newtest 1000 device, and explosive strength was evaluated through vertical jump measurements. These parameters provide insight into the neuromuscular and biomechanical performance characteristics of athletes enrolled in the Faculty of Sport Sciences.

Table 4 presents the Pearson correlation coefficients (r) and significance levels (p) for the relationship between agility (seconds) and reaction time (milliseconds) in male and female athletes.

Table 4. Correlation between agility and reaction time in athletes by gender

Performance	Gender	N	Reaction time (sec)	
			r	*p* value
Agility (sn)	**Male**	68	-0.262*	.031
	Female	52	-0.595**	.000

***Note**. ** (p<0.01); * (p<0.05)*

A moderate negative correlation was observed in male athletes (r = –0.262, p < 0.05) indicating that faster reaction times are associated with better agility performance. In female athletes. a strong negative correlation was found (r = –0.595, p < 0.01) suggesting a more pronounced link between neuromotor responsiveness and directional movement efficiency. These findings support the hypothesis that reaction time is a critical component of agility. particularly in female populations. Table 5 presents the Pearson correlation coefficients (r) and significance levels (p) for the relationship between agility (seconds) and explosive strength (vertical jump height in centimeters) in male and female athletes.

Table 5. Correlation between agility and explosive strength in athletes by gender

Performance	Gender	N	Explosive strength (cm)	
			r	*p* value
Agility	**Male**	68	-0.520**	.000
	Female	52	-0.594**	.000

***Note.** **(p<0.01)*

A strong. statistically significant negative correlation was observed in both groups (male: r = –0.520, p < 0.01; female: r = –0.594, p < 0.01) indicating that higher explosive strength is associated with better agility performance. These findings suggest that lower-body power plays a critical role in rapid directional changes and movement efficiency. reinforcing the biomechanical link between vertical force production and agility-based motor tasks. Table 6 presents the Pearson correlation coefficients (r) and significance levels (p) for the relationship between explosive strength (vertical jump height in centimeters) and reaction time (milliseconds) in male and female athletes.

Table 6. Correlation between explosive strength and reaction time in athletes by gender

Performance	Gender	N	Reaction time (sec)	
			r	p
Explosive strength (cm)	Male	68	0.354**	.003
	Female	52	0.225	.109

Note. **(p<0.05)*

A moderate. statistically significant positive correlation was observed in male athletes ($r = 0.354$, $p < 0.05$) suggesting that greater explosive strength may be associated with longer reaction times. potentially reflecting a trade-off between power generation and neuromotor responsiveness. In contrast. no statistically significant correlation was found in female athletes ($r = 0.225$, $p > 0.05$) indicating that explosive strength and reaction time may operate more independently in this group. These findings highlight gender-specific neuromuscular dynamics and suggest that training interventions may need to be tailored accordingly.

4. DISCUSSION

The present study revealed significant relationships among agility. reaction time. and explosive strength in athletes from various sport disciplines. Specifically. agility showed strong negative correlations with both reaction time and explosive strength. particularly among female athletes. These results support the view that agility is a multifactorial construct involving neuromuscular coordination. perceptual speed. and biomechanical efficiency (Sheppard & Young, 2006; Young et al., 2001; Brughelli et al., 2008).

The strong negative correlation between agility and reaction time in female athletes ($r = –0.595$. $p < 0.01$) suggests that perceptual and decision-making components play a more prominent role in agility performance among female athletes. Similar findings were reported by Çömük & Erden (2010); Ölçici (2007); Şahin et al. (2020). who found that athletes with faster reaction times tend to score higher in agility tests. Akarsu et al. (2009) emphasized that athletes exhibit superior eye-hand reaction times and visuospatial intelligence compared to non-athletes. reinforcing the cognitive dimension of agility. Colcombe & Kramer (2003) further supported that sustained athletic participation enhances cognitive functions across various sports.

In male athletes. the moderate negative correlation between agility and reaction time ($r = –0.262$. $p < 0.05$) may reflect a biomechanical emphasis. where explosive strength contributes more directly to directional movement efficiency. Chaouachi et al. (2009); Alemdaroğlu (2012); Bayraktar (2013) confirmed that vertical jump performance is a reliable predictor of agility in elite athletes.

These findings align with studies by Sassi et al. (2009); Volpi et al. (2017); McFarland et al. (2016). which reported significant associations between vertical jump metrics and agility test outcomes across multiple sports.

The observed strong negative correlation between agility and explosive strength in both genders ($r = –0.520$ to $–0.594$. $p < 0.01$) reinforces the biomechanical foundation of agility. Peterson et al. (2006); Sekulic et al. (2014); Lockie et al. (2020) highlighted that lower-body power and coordination significantly influence change-of-direction speed. Cazorla et al. (2008) and Young et al. (1996) emphasized that coordination may explain up to 50% of unexplained agility performance variance.

Interestingly. the moderate positive correlation between explosive strength and reaction time in male athletes ($r = 0.354$. $p < 0.05$) may indicate a performance trade-off. where increased power generation slightly delays neuromotor responsiveness. Zulfikar (2020); Orhan (2013); Hasçelik et al. (1989) discussed that explosive training improves strength but may not uniformly enhance reaction time. In contrast. the absence of a significant correlation in female athletes suggests that these parameters may operate independently. possibly due to sport-specific demands or neuromuscular variability (Paradis et al., 2002; Yitik, 2018; Zorba et al., 2014).

Beyond statistical significance, effect sizes were calculated using Cohen’s d (see Table 2) to assess the practical relevance of gender-based differences in motor performance parameters. While Cohen’s d values specifically reflect between-group differences, the strength of observed correlations ($r = –0.595$, $r = –0.594$) also suggests practically meaningful relationships—particularly among female athletes—consistent with large effect interpretations. In male athletes, the moderate correlation values indicate a measurable but less dominant interaction. Taken together, these findings emphasize the need for gender-specific training interventions that reflect distinct neuromuscular and biomechanical profiles, particularly in agility-focused sports.

From a methodological standpoint, the study employed validated protocols including the Semenick-modified T-Test for agility (Pauole et al., 2000), the Newtest 1000 device for reaction time (Tamer, 2000), and the Takei vertical jump meter for explosive strength. Although these tools enhance measurement reliability, the absence of test-retest and inter-rater reliability assessments constitutes a limitation. Furthermore, subgroup comparisons across sport disciplines were constrained by sample size, as noted in similar studies (Peterson et al., 2006; Lockie et al., 2020).

Overall, the findings reinforce the value of integrated training programs that simultaneously target agility, explosive strength, and reaction time. Given the large effect sizes observed in explosive strength and agility differences, vertical jump metrics may serve as reliable predictors of agility particularly in male athletes supporting their use in performance monitoring and individualized training design.

This study was limited to 120 active athletes studying at Bartın University Faculty of Sports Sciences. Due to the relatively small sample sizes within individual sport disciplines, subgroup comparisons lacked sufficient statistical power and were therefore excluded from the final analysis. Additionally, test-retest and inter-rater reliability assessments were not conducted, which may affect the generalizability of the findings.

5. CONCLUSIONS

This study demonstrated statistically significant relationships among agility. reaction time. and explosive strength in university athletes across various sport disciplines. The strongest correlations were observed in female athletes. suggesting that neuromotor responsiveness and lower-body power are more tightly linked to agility performance in this group. These findings support the multifactorial nature of agility. which integrates cognitive. neuromuscular. and biomechanical components.

The results also revealed a moderate positive correlation between explosive strength and reaction time in male athletes. indicating a potential trade-off between power generation and response speed. In contrast. no significant correlation was found in female athletes. suggesting gender-specific performance dynamics.

Overall. the study highlights the importance of integrated training programs that simultaneously target agility. explosive strength. and reaction time. These motor parameters should be considered collectively in athlete development strategies. talent identification. and performance monitoring.

6. RECOMMENDATIONS

1. Coaches and trainers should implement multidimensional training programs that develop agility. explosive strength. and reaction time in parallel. especially in sports requiring rapid directional changes.
2. Training protocols should be tailored to gender-specific neuromuscular profiles. as female athletes may benefit more from cognitive and perceptual agility drills. while male athletes

may require biomechanical emphasis.

3. Regular testing of agility. vertical jump. and reaction time should be incorporated into athlete monitoring systems to track progress and guide individualized interventions.
4. Future studies should focus on larger. sport-specific cohorts to explore inter-group differences and validate the observed correlations across disciplines.
5. Subsequent research should include test-retest reliability. inter-rater agreement. and longitudinal designs to strengthen the validity and generalizability of findings.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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