

Reaction time analysis in professional table tennis: gender differences and key determinants

Marcin Szczepański^a, Monika Lopuszanska-Dawid^a, Paulina Kubot^a

^aDepartment of Human Biology, Faculty of Physical Education, Józef Piłsudski University of Physical Education in Warsaw, Poland

Purpose: The purpose of study was to identify the factors influencing the visuomotor reaction time of elite male and female players and to assess the magnitude of sex-based differences in reaction times.

Methods: Methods: The study involved 64 participants: 44 elite Polish table tennis players (female n=17, male n=27) athletes; female and male students as the control group (n=20). Data on socioeconomic status, physical activity and subjective physiological state were collected using an author-designed questionnaire. Anthropometric data were collected. Reaction time was measured using the Piórkowski's apparatus. The analyses included Chi2 tests, Student's t-tests for independent samples, Spearman's rank correlation and multiple regression analyses.

Results: Significant differences were found in the number of points scored between female table tennis players and female students (137 vs 126 $P=.013$) and between female and male table tennis players (137 vs 129, $P=.023$), while no significant differences were observed among male participants. Gender differences were identified in the urbanization of residence ($P=.034$), participation in additional sports disciplines ($P=.013$), and anthropometric features such as body height, body mass and Waist to Hip Ratio ($P=.001$). Among female athletes, moderate negative correlations were found between speed of reaction and training session duration ($R=-.559$) and body height ($R=-.489$), suggesting shorter training sessions and lower body height may enhance reaction time. No significant associations between reaction time and the analyzed variables were observed among male athletes.

Conclusions: The analyses revealed differences in place of residence, participation in additional sports disciplines, hunger perception, and somatic build between female and male athletes. The study demonstrated that certain factors influence reaction time. Appropriate training duration combined with adequate intensity can improve the reaction time of athletes. The obtained results may serve as a foundation for further research and observations of table tennis players.

Keywords: reflex; reaction time; table tennis; racket sport; table tennis performance

Introduction

Table tennis is one of the most popular racket sport.¹ This discipline, where matches are played indoors on specialized tables equipped with a net, is regarded as one of the most dynamic sports – the ball can reach speeds of up to 140 km/h,² with ball-racket contact lasting approximately 0.8 milliseconds.³ The unique nature of table tennis demands a wide array of attributes and skills. These include aerobic and anaerobic fitness, speed, strength, agility, flexibility, motor coordination, mental resilience, technical and tactical skills, perception and action abilities, as well as situational awareness and control.⁴

A high level of motor abilities is fundamental to competing at the highest levels of sport. Moreover, the development of motor skills is associated with numerous psychological, physiological, and behavioral benefits and it may also influence executive functions.⁵ However, it has been noted that in addition to general motor fitness, high-level skill sports are characterized by well-developed visuomotor coordination and visuospatial processing adeptness.⁶

In racket sports, reaction time is a critical factor,⁷ influenced by factors such as the type of stimulus, the mobility of the nervous system and external factors.⁸ The ability to respond quickly to external stimuli, coupled with the resulting speed and precision of movement, is crucial for every stroke of the ball.

Consequently, the ability to rapidly react to stimuli, combined with a high level of coordination, is considered a fundamental basis for success in competitive sports.⁹ Reaction time can be improved through training, however certain components are not trainable, as the conduction velocity of neural impulses along nerve pathways remains relatively constant.^{8,10,11}

Research confirms that there is a difference in reaction time between individuals who engage in training and those who do not participate in physical activity.¹² A group of researchers from Taiwan demonstrated that karate athletes achieved shorter reaction times with both their dominant and non-dominant hands in a hand-eye coordination test compared to taekwondo athletes and non-training individuals.¹³

The maturation process is associated with an improvement in simple reaction time across both sexes, although studies consistently report a male advantage in this domain.⁷ However, reaction time demonstrates a decline with increasing age. This trajectory is frequently modeled as a U-shaped curve, characterized by prolonged reaction times in children and older adults, and optimal reaction times observed in young adults.¹⁴

Anthropometric characteristics, including somatic structure, can significantly influence reaction time. Empirical evidence highlights the role of stature in determining reaction time, with findings indicating a negative correlation between body height and reaction latency.¹⁵ Body mass also exerts a positive influence

on reaction performance, with individuals within a healthy weight range exhibiting superior reaction times compared to those classified as obese.¹⁶

Sleep quality and duration are pivotal determinants of athletic performance.¹⁷ Optimal sleep is essential for enhancing physical efficiency and facilitating post-exercise recovery. However, factors such as skin temperature and perspiration during sleep can substantially impair sleep quality,¹⁸ while ambient room temperature may exert variable effects, either positive or negative effects.¹⁹ Perspectives on the role of sleep have evolved over time. Despite advancements in sleep science, our comprehension of its extensive influence on physiological and cognitive processes remains in its nascent stages.^{20,21}

Nutritional strategies, including proper diet and meal timing pre- and post-exercise, are integral to optimizing athletic performance. Nutrition plays a critical role in regulating nearly every physiological processes, ranging from energy metabolism to recovery dynamics following physical exertion.²² Conversely, irregular meal patterns have been associated with diminished performance outcomes.²³

Investigating the determinants of visuomotor reaction time in high-performance table tennis necessitates comprehensive and methodologically depth analyses. The objective of this study was to identify the factors influencing visuomotor reaction time among elite male and female athletes while quantifying the extent of sex-based differences in reaction times.

Methods

Participants

The study involved 64 participants, including 44 elite Polish table

tennis players, comprising 17 female and 27 male athletes (aged 16 to 36 years). The athletes included in the study had to meet the criterion of competing in the highest league level, being selected for the broader national team, or qualifying for the finals of the Polish Championships, meaning they ranked among the top 48 players in Poland. All data collection was conducted between March and May 2024 in Grodzisk Mazowiecki, Nadarzyn, and Warsaw (Poland) before the Polish Championships, as well as in Gdańsk during the Polish Championships. Among the athletes were members of the broader Polish national team, including 17 from the senior team, 5 from the under 22 team, 9 from younger national squads, and 2 former members of the national team. The control group consisted of female (n=10) and male (n=10) students from the Józef Piłsudski University of Physical Education in Warsaw, Poland (aged 21 to 38 years). The control group was tested in May 2024 in Warsaw (Poland). The average number of training sessions per week for the control group is 3, lasting 95 minutes each. The main declared sports disciplines are football and swimming. In both groups, about 95% of the participants reported right upper limb dominance (right-handedness).

Inclusion criteria included: (1) informed consent (from participants or guardians of minors); (2) age between 16 and 40 years; (3) for the athlete group – participation at the highest competitive level; and (4) for the control group – current enrollment in the Faculty of Physical Education at the Józef Piłsudski University of Physical Education.

No statistically significant differences in age were observed either within or between the athlete and control groups by gender (see Table 1).

Table 1. Age distribution and average results from the Piórkowski's apparatus of table tennis players and control group by gender

	Women		Men		Sex differences	
	TTP n=17	CG n=10	TTP n=27	CG n=10	TTP	CG
Age distribution						
M±SD	22.49±6.13	25.00±5.31	21.70±4.08	22.50±2.07	<i>P</i> = .425	<i>P</i> = .425
	<i>P</i> = .385		<i>P</i> = .562		-	-
	<i>t</i> = -1.08		<i>t</i> = -0.59		<i>t</i> = 0.51	<i>t</i> = 1.39
	Cohen's <i>d</i> = -.43		Cohen's <i>d</i> = -.22		Cohen's <i>d</i> = -.16	Cohen's <i>d</i> = .62
Average results from the Piórkowski's apparatus						
Number of points	137	126	129	124	<i>P</i> = .023**	<i>P</i> = .493
	<i>P</i> = .013*		<i>P</i> = .168			
	<i>t</i> = 2.68		<i>t</i> = 1.41		<i>t</i> = 2.36	<i>t</i> = .70
	Cohen's <i>d</i> = 1.07		Cohen's <i>d</i> = .47		Cohen's <i>d</i> = .73	Cohen's <i>d</i> = .23
Number of errors	2	1	2	1	<i>P</i> = .825	<i>P</i> = .487
	<i>P</i> = .290		<i>P</i> = .107			
	<i>t</i> = 1.08		<i>t</i> = 1.65		<i>t</i> = .22	<i>t</i> = .71
	Cohen's <i>d</i> = .43		Cohen's <i>d</i> = .61		Cohen's <i>d</i> = .07	Cohen's <i>d</i> = .32

Legend: TTP – Table Tennis Players; CG– Control Group; n – Sample size; M – Mean; SD – Standard Deviation; *t* – *t*-value from Student's *t*-test; Cohen's *d* - Effect size measure for the difference between two means: .2 – small effect; .5 – medium effect; .8 – large effect.

Methodology

Instruments

Researcher-designed instrument

Using an author-designed questionnaire and the direct interview method, comprehensive socio-economic data were collected. These included: gender (response options: male, female); age (measured in years); place of residence (categorized as rural, urban areas with up to 20,000 inhabitants, urban areas with 20,000–50,000 inhabitants, or cities with over 100,000 inhabitants); level of education (classified as primary, secondary, incomplete higher, or higher education); and marital status (categorized as single without a partner, in an informal partnership, or in a formal marital union). Furthermore, data pertaining to specific aspects of physical activity were recorded, including training experience (in years), the frequency of weekly training sessions, the duration of each training session (in minutes), and engagement in additional sports disciplines (response options: yes, no). The questionnaire also included questions about subjective physiological state, such as whether the person felt rested or hungry and whether they ate breakfast (response options: yes or no). Additionally, it contained a question about the number of hours (h) slept within 24 hours on the test day.

A pilot study was conducted on 10 individuals, and the results were not included in the main study. The pilot study allowed for the assessment and optimization of the research tool (the questionnaire) as well as the procedures related to its distribution and data collection, which increased the chances of obtaining reliable and valuable data in the main study.

The study was conducted using a questionnaire-based research survey through direct diagnostic interviewing. The interviewer was trained in the standard procedure for conducting interviews to ensure consistency in data collection (standard protocol). Respondents were given clear instructions on how to answer, and closed-ended questions were used to obtain precise data.

Reaction time measurement - Piórkowski's apparatus

The primary research instrument utilized in this study was the Piórkowski Reaction Time Tester (brand product: Alfa-Electronics, Driver Psychological Laboratory, Ustrzyki Dolne, Poland), a device designed to measure visuomotor coordination and psychophysical efficiency. The Piórkowski apparatus reaction time test is used in various fields, such as sports psychology, neurological diagnostics, transport psychology, and occupational medicine, to assess psychomotor efficiency and visual-motor coordination. It is compliant with the guidelines outlined in the *Announcement of the Polish Minister of Health of 24th November 2021*, regarding psychological assessments for individuals seeking driving licenses, professional drivers, and those performing work-related driving duties. The device allows for testing under both fixed-rate conditions (stimuli per minute) and self-paced conditions. The testing duration can be configured for 30, 60, 90, or 120 seconds or for specific stimulus counts of 30, 50, 70, or 90 stimuli. It automatically calculates key parameters, including the total number of stimuli presented, the number of correct responses, missed stimuli, incorrect responses, and the time taken to complete the task.

For this study, a self-paced testing mode was employed with a measurement duration of 60 seconds. This specific configuration was chosen to facilitate the precise assessment of reaction time among elite table tennis players under standardized conditions. The reaction time test using the Piórkowski apparatus in a variable tempo, with a test duration of 60 seconds, involves measuring the reaction time of the subject to light stimuli that

appear at random and irregular intervals. Lamps light up in a random sequence on the Piórkowski apparatus (one of ten lamps lights up). The subject's task is to press the corresponding button under the lit lamp as quickly as possible. The apparatus registers the number of correct presses. Errors, i.e., incorrect button presses, are also recorded. The correct points obtained represent the test result. A higher number of correct points leads to a better outcome, which in turn results in a better average reaction time. This test design simulates situations where a reaction must be fast and adaptable to changing conditions. The 60-second test duration is a standard test length that allows for reliable results. The measurement was conducted under controlled conditions to minimize the influence of external factors. To avoid the effects of fatigue or learning, the main trial was conducted only once, with participants being thoroughly instructed on its rules and procedure. The person conducting the test was properly trained in the operation of the apparatus. The apparatus was regularly calibrated according to the manufacturer's requirements.

Anthropometric measurements

Body height was measured with the AGP Anthropometer (a Martin-type anthropometer) (brand product: GPM instruments GmbH, Susten, Switzerland) to an accuracy of 0.1 cm, with participants standing barefoot in an upright position, measured from the *Basis* to the *vertex* anthropometric point (with the required head positioning in the Frankfurt plane). Body mass was assessed using a flat digital scale SECA 875 with a precision of 0.01 kg (brand product: SECA gmbh & co. kg, Hamburg, Germany). The subjects were measured in the morning, in very light clothing (e.g. underwear), without shoes. Waist circumference was measured using the GMP Analog Ruler Measuring Tape (brand product: GPM instruments GmbH, Susten, Switzerland) positioned at the midpoint between the lowest rib and the upper edge of the iliac crest. Similarly, hip circumference was determined using a tape measure, aligned over the greatest protrusion of the gluteal muscles. All measurements were conducted following standardized Martin technique procedures, which are widely applied in population-based research.^{24,25} Based on anthropometric measurements calculated Waist Hip Ratio (WHR = waist circumference [cm]/hip circumference [cm]) and Body Mass Index (BMI = body mass [kg]/height² [m]).

Statistical analysis

Basic statistical methods were employed for data analysis, using the Statistica 13.3 software package (TIBCO Software Inc., Statistica (data analysis software system), version 13. <http://statistica.io>, United States).²⁶ Descriptive statistics were presented, including mean values, standard deviations, and minimum and maximum values. The Shapiro-Wilk test was performed to verify whether the distribution of study variables followed a normal distribution. The obtained results indicated that there is no basis to reject the null hypothesis of normality of the distribution. The analyses included: Chi-square tests (for assessing the significance of differences in the distributions of qualitative variables between groups), Student's *t*-tests for independent samples (for assessing differences in mean age, anthropometric characteristics, number of points scored, and quantitative characteristics of physical activity between groups within each sex), Spearman's rank correlation (as it is based on ranks rather than absolute values, it is significantly more sensitive to outliers) and multiple regression analyses (independent variables: sociocconomic, physical activity, subjective physiological state and anthropometric data, dependent variables: number of points scored in 90 seconds). The level of $\alpha = 0.05$ was set to evaluate the significance of differences and

Table 2. Characteristics of anthropometric features of male and female table tennis players.

Variables	Men			Women			<i>P</i>	<i>t</i>	Cohen's <i>d</i>
	M±SD	Min.	Max.	M±SD	Min.	Max.	<i>P</i>		
Body height (cm)	168.2±5.7	160.0	178.0	181.3±6.7	165.0	196.0	.001***	-6.93	2.07
Body mass (kg)	61.1±6.2	51.0	74.0	73.8±8.2	53.0	88.0	.001***	-5.47	1.69
Waist circumference (cm)	74.9±6.6	66.0	87.0	84.4±5.2	76.0	94.0	.001***	-5.31	1.65
Hips circumference (cm)	88.8±7.1	78.0	100.0	91.4±5.8	79.0	101.0	.186	-1.33	.41
BMI (kg/m ²)	21.6±1.5	18.7	24.2	22.4±2.0	18.4	25.2	.133	-1.43	.47
WHR (cm)	.8±.1	.7	1.0	.9±.1	.8	1.0	.001***	-3.23	1.0

Legend: M – Mean; SD – Standard Deviation; Min.- Minimum; Max. – Maximum; BMI – Body Mass Index, WHR – Waist Hip Ratio; *P*—*p*-value, level of statistical significance: **P*≤ .05, ***P*≤ .01 and ****P*≤ .001; *t* – *t*-value from Student's *t*-test; Cohen's *d* - Effect size measure for the difference between two means: .2 – small effect; .5 – medium effect; .8 – large effect.

correlations. R-squared values of determination for multiple regression models have been given.²⁷

Results

Characteristics

Age distribution and characteristics of anthropometric features of table tennis players and control group by gender have been presented in tables 1 and 2.

Reaction time of table tennis players and the control group

Table 1 presents the averages of the results obtained: the number of points and errors recorded for female and male table tennis players, as well as female and male students from the control group. Significant differences were identified between female table tennis players and female students in the number of points scored (137 vs. 126, respectively, *P*= .013; *t* = 2.68; *d* Cohen = 1.07) and female table tennis players and male table tennis players in the number of points scored (137 vs. 129, respectively, *P*= .023; *t* = 2.36; *d* Cohen = 0.73). No statistically significant differences were observed among the male participants in the analyzed characteristics.

Socioeconomic status, physical activity status, subjective physiological state and anthropometric of male and female table tennis players

Table 3 presents data on the socioeconomic status, physical activity status (training experience, weekly training time, and participation in additional sports disciplines), subjective physiological state of male and female table tennis players. Statistically significant differences were observed exclusively in the **degree of urbanization of the place of residence** between male and female players.

The average training experience for both women and men ranged between 14 and 15 years. Statistical analysis confirmed no significant differences between the groups (*t* = 0.53, *P* = 0.596), and the effect size was very small (Cohen's *d* = 0.15), indicating a negligible influence of gender on training experience (Table 3). Weekly training time was higher in men (1266±489 min) than in women (1091±562 min). This difference did not reach the level of statistical significance (*t* = -1.09, *P* = 0.281), and the effect size was small (Cohen's *d* = 0.34), suggesting a minor, non-significant influence of gender on weekly training time (Table 3). However, men were significantly more likely than women to

Table 3. Characteristics of the socioeconomic status, subjective physiological state and physical activity status of male and female table tennis players

	Women		Men		Chi ² <i>P</i>
	n	%	n	%	
Socioeconomic status					
Level of education					
high	3	17.6	2	7.4	1.15 .766
incomplete higher	2	11.8	4	14.8	
secondary	7	41.2	13	48.1	
primary	5	29.4	8	29.6	
Marital status					
in a formal relationship/ married	2	11.8	3	11.1	.15 .993
in an informal relationship	6	35.3	10	37.0	
single/without a partner	9	52.9	14	51.9	
Degree of urbanization of place of residence					
city over 100,000 inhabitants	12	70.6	20	74.1	8.68 .034*
city with 20,000 - 50,000 inhabitants	1	5.9	7	25.9	
city with up to 20,000 inhabitants	2	11.8	0	0	
village	2	11.8	0	0	

Subjective physiological state					
Feeling rested					
yes	8	47.1	18	66.7	1.65
no	9	52.9	9	33.3	.200
Number of hours (h) slept per 24 hours on test day					
4	0	0	1	3.7	Woman
5	2	11.8	1	3.7	8.44
6	3	17.6	5	18.5	.078
7	5	29.4	4	14.8	Men
8	6	35.3	13	48.2	10.85
9	1	5.9	3	11.1	.093
Do you feel hungry?					
yes	8	47.1	5	18.5	4.03
no	9	52.9	22	81.5	.040*
Did you eat breakfast?					
yes	15	88.2	25	92.6	.23
no	2	11.8	2	7.4	.641
Physical activity					
Do you participate in additional sports disciplines?					
yes	15	88.2	14	51.9	6.15
no	2	11.8	13	48.1	.013**
Training experience (years)					
	M±SD	14.6±5.4	13.9±4.1		.596
	Min.-Max.	9.0-27.0	6.0-22.0	$t = .53$ Cohen's $d = .15$	
Weekly training time (min.)					
	M±SD	1091±562	1266±489		.281
	Min.-Max.	240-1980	270-2400	$t = -1.09$ Cohen's $d = .34$	

Legend: M – Mean; SD – Standard Deviation; Min.- Minimum; Max. – Maximum; BMI – Body Mass Index, WHR – Waist Hip Ratio; P —p-value, level of statistical significance: * $P \leq .05$, ** $P \leq .01$ and *** $P \leq .001$; t – t -value from the Student's t -test; Cohen's d - Effect size measure for the difference between two means: .2 – small effect; .5 – medium effect; .8 – large effect.

report participation in an additional sport discipline ($P = .013$). In the subjective physiological state, it was noted that women were significantly more likely than men to report feeling hungry before the examination ($P = 0.040$). No significant differences were observed in the feeling of being well-rested, the duration of sleep, or breakfast consumption.

Among female athletes, no strong or very strong correlations were observed. However, moderate negative correlations were identified between response time and both training session duration ($R = -.559$) and body height ($R = -.489$). These findings indicate that shorter training sessions and lower body height are associated with better speed of reaction. In the group of male athletes, no strong or moderate correlations were detected. The highest positive correlation among men was observed for age ($R = .243$), and the highest negative for training duration ($R = -.215$), however, in both cases, the correlation was weak (Table 4).

The results present three-factor multiple regression analyses conducted separately for male and female athletes within homogeneous groups of variables, including socio-economic factors, physical activity, subjective physiological state, and

somatic characteristics (Table 4). The analyses accounted for intercorrelations among variables within each group, ensuring that results were presented after eliminating mutual dependencies. No significant associations were observed between reaction time and the analyzed variables in either factors group (socio-economic, physical activity, comfort, and somatic parameters). The strongest associations among female athletes were noted for the duration of a single training session, followed by body height as the second most relevant factor (with the highest degree of significance, approaching $P = .05$). With increasing body height and weekly training time, the number of points scored — and thus the reaction time speed of women — decreased. A similar pattern related to body height was observed among men. The highest values of the coefficients of determination (R^2) among all models, reaching even over 0.32, were recorded in the group of women (excluding socio-economic factors), in the following order for: anthropometric features, physical activity and biological comfort. Thus, anthropometric characteristics, physical activity, and biological comfort have a stronger impact on the dependent variable in women than in men. Among men, the coefficients of determination, excluding socio-economic

Table 4. Relationships between reaction time (number of points scored in 60 seconds) and socio-economic variables, physical activity, biological characteristics, subjective physiological state and anthropometric features

Variables groups	Variables	Women				Men			
		Spearman's R				Spearman's R			
AGE	age	-.097				.243			
PHYSICAL ACTIVITY	duration of training experience	.040				.132			
	training time	-.559				-.215			
ANTHROPOMETRIC FEATURES	body height	-.489				-.139			
	BMI	-.251				-.008			
	WHR	.329				-.158			

N women=17 N men= 27	Female players					Male players				
	b*	Stand. Error	b	Stand. Error	P	b*	Stand. Error	b	Stand. Error	P
SOCIOECONOMIC										
Intercept			133.20	20.64	.001			117.07	19.16	.001
Place of residence	-.07	.28	-.72	2.81	.802	.18	.20	4.35	4.82	.375
Education level	.13	.32	1.38	3.38	.691	.19	.20	2.41	2.46	.338
Marital status	.09	.32	1.43	5.10	.784	-.24	.20	-3.76	3.11	.228
R ²			.02					.13		
PHYSICAL ACTIVITY										
Intercept			156.45	12.38	.001			130.27	15.53	.001
Training experience	-.14	.26	-.29	.54	.598	.01	.24	.03	.64	.961
Weekly training time	-.53	.26	-.01	.01	.059	-.29	.24	-.01	.01	.232
Additional sports disciplines	-.08	.25	-2.86	8.53	.742	.21	.21	4.50	4.48	.326
R ²			.28					.10		
SUBJECTIVE PHYSIOLOGICAL STATE										
Intercept			156.13	24.50	.001			143.23	21.18	.001
Feeling rested	.07	.28	1.61	6.14	.798	.07	.24	1.67	5.53	.766
Number of hours of sleep	-.26	.28	-2.42	2.65	.378	-.15	.24	-1.27	2.08	.548
Feeling of fullness	-.12	.28	-2.72	5.94	.654	-.14	.21	-3.88	5.71	.503
R ²			.12					.06		
ANTHROPOMETRIC FEATURES										
Intercept			240.43	95.15	.025			243.85	94.78	.017
Body height	-.36	.23	-72.37	46.34	.142	-.23	.22	-37.82	35.80	.302
BMI	-.20	.23	-1.53	1.76	.400	.09	.20	.49	1.12	.668
WHR	.33	.23	61.06	42.64	.176	-.29	.22	-61.78	47.61	.207
R ²			.32					.09		

Legend: Spearman's R - Spearman's rank correlation coefficient; b* – unstandardized regression coefficient in Multiple Regression Results; b - standardized regression coefficient in Multiple Regression Results; Stand. Error – Standard error in Multiple Regression Results; R² - coefficient of determination; P—p-value, level of statistical significance: *P≤ .05, **P≤ .01 and ***P≤ .001

factors, were lower than in women and followed a different pattern in the order of variance explanation for the dependent variable (socio-economic factors, physical activity, comfort, and anthropometry).

Discussion

This study identified a significant difference in the number of points scored between female and male table tennis players, as well as between women who train professionally and those who do not engage in table tennis training. In both cases, the observed significance favored female professional players, indicating that female athletes exhibit better speed of reaction compared to their male counterparts and non-training women. The analyses also revealed significant differences between male and female players in terms of place of residence, participation in additional sports disciplines, sensation of hunger, and somatic characteristics. Among women, a moderate correlation was observed between reaction time and both training duration and body height, while weaker associations were found for BMI and WHR. In contrast, among men, reaction time was influenced by age and training duration, although the strength of these relationships proved to be relatively weak.

Current studies indicate that individuals engaged in regular training demonstrate faster simple reaction times compared to non-training individuals.²⁸ However, in this study, a significant difference was observed specifically within the group of women. In contrast, no significant differences were found within the group of men.

The topic of reaction time and gender differences has been investigated since the 20th century. Previous research have consistently reported that males achieve shorter simple reaction times. This trend persists both among adolescents⁷ and adults.²⁹ It was observed that female athletes achieved better reaction time results than male athletes.

In the study investigating the effect of age on reaction time, no significant relationship was observed in female athletes, whereas a weak correlation was noted in male athletes. Although numerous studies indicate that age influences reflexes,⁷ researchers often describe this relationship using a U-shaped curve, with longer reaction times observed in children and older adults, and shorter reaction times in young adults.¹⁴

Training duration proved to be a relatively weak modifier in men, while a moderate correlation was observed in women. However, in both male and female athletes, the correlation was negative, indicating that shorter training sessions were associated with better performance in the study. The topic of the impact of training duration and professional experience on reaction time remains insufficiently studied, and no definitive conclusions can be drawn regarding whether training duration or professional experience significantly influences reaction time. Although no correlation was identified between professional experience and reaction time in either female or male athletes, a significant difference was observed in performance scores between female athletes and non-athletes, which may be attributable to the influence of professional experience. Furthermore, previous studies have demonstrated significant differences in reaction times across various sports disciplines, such as football and volleyball,³⁰ as well as between closely related disciplines, such as table tennis and badminton.³¹

The findings of this study may support the notion that each sport discipline, through its specific characteristics, develops distinct skills and abilities, which could explain the observed differences between female athletes and non-athlete students. The

relationship with training duration, however, is more complex, as the temporal structure of training sessions for professional table tennis players is not well understood. It remains unclear how frequently, or even if, their training microcycles include sessions specifically aimed at improving visuomotor reaction time. Undoubtedly, playing table tennis positively influences various traits and attributes.^{4,32} However, drawing definitive conclusions is not feasible, as training comprises numerous components and cannot be reduced to a single factor.

The examined group of women demonstrated a moderate negative correlation between body height and reaction time, indicating that taller individuals tended to exhibit slower reaction time. In contrast, no such relationship between body height and reaction time was observed in men. However, previous studies^{15,33} have reported a similar negative correlation between body height and reaction time. Future research should consider a larger sample size, as previous publications included a greater number of participants compared to the present study.

The analyses conducted in this study did not confirm any influence of BMI or WHR on reaction time in men. However, in women, a weak correlation was observed between these variables and reaction time, with BMI showing a negative correlation and WHR exhibiting a positive correlation. In the study by Nikam and Gadkari,³⁴ higher BMI was found to be associated with prolonged reaction times. Similarly, other scientific studies have also confirmed the impact of BMI on reaction time.^{16,35,36} There is a limited number of scientific studies addressing the relationship between WHR and reaction time, and no definitive evidence exists to confirm or deny such a correlation. A potentially relevant factor could be the balance between androgen and estrogen levels, which influences WHR values. In this study, all female athletes had a normal relative body mass, while the vast majority of male athletes also fell within this range. To fully evaluate the impact of BMI, the sample would need to include individuals with underweight, overweight, and obesity. However, such cases are rare among elite athletes, as observed in this study. Similarly, the small number of women with gynoid fat distribution and men with android fat distribution could explain the lack of observed effects of WHR on reaction time.

This study reveals several limitations that should be considered in future research. The first limitation is the testing environment, as variations in testing conditions could have influenced reaction time measurements. Ensuring consistent and comfortable conditions for all participants is a critical factor. Another limitation is the time of day, which may have affected the results. Participants tested in the morning and afternoon were in different phases of their daily routine, potentially impacting their performance. It is worth noting that the aspects of sleep quality were not thoroughly examined, only its duration. Additionally, the lack of standardization in the testing period represents another variable that could have influenced the outcomes.

There are observable differences in athlete performance between the pre-start and start phases. A critical aspect of this study is the size of the sample group, which was specifically narrowed to include only the elite female and male athletes in Poland. Additionally, factors such as motivation and attitude toward achieving competitive results must be accounted for, as the absence of a standardized operational framework may lead to inconsistent or suboptimal outcomes. Understanding the specificity and capabilities of the device allows for the implementation of more advanced measurements, such as conducting tests at a predetermined pace or assessing the time required to press 10, 30, or 60 points.

Practical Applications

Appropriately timed training focused on reaction time and speed can yield positive outcomes. An essential aspect of such training involves optimizing both the duration of exercises and the rest periods between them, alongside the careful selection of training methods. Commonly utilized methods include the maximum-intensity repetition method, the submaximal-speed method, and various forms of interval training. The choice of methods should be guided by the specific goals established jointly by the athlete and coach.

In table tennis training, partner rotations during drills are frequently employed to ensure the comprehensive development of all players' skills. To adjust the training intensity to the reaction abilities of the female athletes, their height can be taken into account, allowing the training session intensity to be tailored to their individual physical characteristics.

These findings support the integration of targeted visuomotor training components into table tennis programs, particularly for female athletes, where anthropometric and perceptual-motor relationships appear more pronounced.

Conclusions

The conducted study and the obtained results facilitated a comprehensive comparison of reaction time (quantified as the number of points scored within 60 seconds), socio-economic status, physical activity levels and somatic characteristics of male and female athletes. Additionally, the relationships between reaction time and a range of factors, including biological traits, socio-economic conditions, subjective physiological state and somatic structure, were analyzed.

The findings revealed statistically significant differences between male and female athletes in terms of place of residence, participation in additional sports disciplines, feelings of hunger and somatic characteristics. This study provided evidence that specific factors influence reaction time. Variables with moderate statistical significance may be considered critical for designing training protocols in table tennis. Optimizing training duration and intensity could enhance athletes' reaction time. Moreover, incorporating body height as a criterion for matching players could help tailor training intensity to individual capacities. The findings of this study may serve as a valuable foundation for future research and longitudinal observations of male and female table tennis players.

Acknowledgments

I would like to thank all the athletes and students examined for their time, as well as the coaches and presidents for making the examination possible.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Ethical Committee approval

Senate Ethics Committee for Scientific Research of the Józef Piłsudski University of Physical Education in Warsaw (Code number: SKE 01-5/2020)

ORCID

Szczepański Marcin ORCID ID <http://orcid.org/0009-0000-6245-0515>

Lopuszanska-Dawid Monika ORCID ID <http://orcid.org/0000-0002-3533-5754>

Kubot Paulina ORCID ID <http://orcid.org/0000-0002-5690-563X>

Topic

Sport Science

Conflicts of interest

The authors declare no conflict of interest.

Funding

Research conducted without external sources of research funding.

Author-s contribution

Conceptualization, M.S. and M.L-D.; methodology, M.S. and M.L-D; software, M.S.; validation, M.S. and M.L-D.; formal analysis, M.S. and M.L-D.; investigation, M.S; resources, M.S.; data curation, M.S., writing—original draft preparation, M.S. M.L-D., and P.K.; writing—review and editing, M.S. M.L-D., and P.K. ; visualization, M.S. M.L-D., and P.K.; supervision, M.S. M.L-D., and P.K.; project administration, M.L-D. All authors have read and agreed to the published version of the manuscript.

References

1. González-Devesa D, Sanchez-Lastra MA, Pintos-Barreiro M, Ayán-Pérez C. Benefits of Table Tennis for Children and Adolescents: A Narrative Review. *Children*. 2024; 11(8):963. doi.org/10.3390/children11080963
2. Hudetz R. *Tenis Stołowy*. Medest; 2005.
3. Russell D. Vibroacoustic analysis of table tennis rackets and balls: The acoustics of ping pong. *J. Acoust. Soc. Am.* 2017;141:3979. doi:10.1121/1.4989082
4. Starzak M, Niżnikowski T, Biegajło M, et al. Attentional focus strategies in racket sports: A systematic review. *PLoS One*. 2024;19(1):e0285239. doi:10.1371/journal.pone.0285239
5. Bao R, Wade L, Leahy AA, et al. Associations Between Motor Competence and Executive Functions in Children and Adolescents: A Systematic Review and Meta-analysis. *Sports Med*. 2024;54(8):2141-2156. doi:10.1007/s40279-024-02040-1
6. Di X, Zhu S, Jin H, et al. Altered resting brain function and structure in professional badminton players. *Brain Connect*. 2012;2(4):225-233. doi:10.1089/brain.2011.0050
7. Waldziński T, Waldzińska E, Durzyńska A, Niespodziński B, Mieszkowski J, Kochanowicz A. One-year developmental changes in motor coordination and tennis skills in 10–12-year-old male and female tennis players. *BMC Sports Science, Medicine and Rehabilitation*. 2024;16(1):190. doi:10.1186/s13102-024-00978-3
8. Sozański H, Sadowski J, Czerwiński J, eds. *Podstawy*

- teorii i technologii treningu sportowego. T. 2. Akademia Wychowania Fizycznego Józefa Piłsudskiego w Warszawie. Filia w Białej Podlaskiej.; 2015.
9. Mancini N, Di Padova M, Polito R, et al. The Impact of Perception–Action Training Devices on Quickness and Reaction Time in Female Volleyball Players. *J. funct. morphol. kinesiolog.* 2024;9(3):147. doi:10.3390/jfmk9030147
 10. John M. The impact of fencing training symmetrisation on simple reaction time. *Biomed. Hum. Kinet.* 2021;13(1):231-236. doi:10.2478/bhk-2021-0028
 11. Ramu V, Lakshminarayanan K. Effect of multi-digit tactile imagery training on reaction time. *Biomed. Hum. Kinet.* 2024;16(1):210-218. doi:10.2478/bhk-2024-0022
 12. Hülsmüller T, Strüder HK, Mierau A. Visual Motion Processing Subverts Faster Visuomotor Reaction in Badminton Players. *Med Sci Sports Exerc.* 2017;49(6):1097-1110. doi:10.1249/MSS.0000000000001198
 13. Chen WY, Wu SK, Song TF, et al. Perceptual and Motor Performance of Combat-Sport Athletes Differs According to Specific Demands of the Discipline. *Percept Mot Skills.* 2017;124(1):293-313. doi:10.1177/0031512516681342
 14. Yao Y, Luo R, Fan C, Qian Y, Zang X. Age-related contextual cueing features are more evident in reaction variability than in reaction time. *Q J Exp Psychol (Hove)*. Published online June 5, 2024;17470218241241954. doi:10.1177/17470218241241954
 15. Šliž M, Paško W, Dziadek B, et al. The influence of selected anthropometric parameters on psychomotor abilities among professional Rugby Union players. *BMC Sports Sci., Med. Rehabil.* 2023;15(1):125. doi:10.1186/s13102-023-00735-y
 16. Nieczuja-Dwojaka J, Marchewka J, Siniarska A, Budnik A, Popielarz K, Tabak I. Influence of body build on hand grip strength, simple reaction time and strength of the abdominal muscles in prepubertal children. *Anthropol Anz.* 2023;80(2):151-158. doi:10.1127/anthranz/2023/1591
 17. Kirschen GW, Jones JJ, Hale L. The Impact of Sleep Duration on Performance Among Competitive Athletes: A Systematic Literature Review. *Clin J Sport Med.* 2020;30(5):503-512. doi:10.1097/JSM.0000000000000622
 18. Troynikov O, Watson C, Nawaz N. Sleep environments and sleep physiology: A review. *J. Therm. Biol.* 2018;78. doi:10.1016/j.jtherbio.2018.09.012
 19. Lan L, Lian ZW, Qian XL, Dai CZ. The effects of programmed air temperature changes on sleep quality and energy saving in bedroom. *Energy Build.* 2016;129:207-214. doi:10.1016/j.enbuild.2016.08.001
 20. Fullagar HHK, Skorski S, Duffield R, Hammes D, Coutts AJ, Meyer T. Sleep and athletic performance: the effects of sleep loss on exercise performance, and physiological and cognitive responses to exercise. *Sports Med.* 2015;45(2):161-186. doi:10.1007/s40279-014-0260-0
 21. Schneider L. Anatomy and Physiology of Normal Sleep. In: *Sleep and Neurologic Disease*. 2017:1-28. doi:10.1016/B978-0-12-804074-4.00001-7
 22. Gökensel P, Yıldız E. The Validity and Reliability Study of the Turkish Version of the General and Sport Nutrition Knowledge Questionnaire (GeSNK). *Progress in Nutrition.* 2021;23 (1):1:e2021027. doi:10.23751/pn.v23i1.10029
 23. Fekih S, Zguira MS, Koubaa A, et al. The Impact of a Motor Imagery-Based Training Program on Agility, Speed, and Reaction Time in a Sample of Young Tennis Athletes during Ramadan Fasting: Insights and Implications from a Randomized, Controlled Experimental Trial. *Nutrients.* 2020;12(11):3306. doi:10.3390/nu12113306
 24. Lopuszanska-Dawid M, Szklarska A. Growth change in Polish women: Reduction of the secular trends? *PLOS ONE.* 2020;15(11):e0242074. doi:10.1371/journal.pone.0242074
 25. Martin R, Saller K. *Lehrbuch der Anthropologie in systematischer Darstellung mit besonderer Berücksichtigung der anthropologischen Methoden*. Stuttgart, G. Fischer; 1957. Accessed December 3, 2024. <http://archive.org/details/lehrbuchderanthr00mart>
 26. TIBCO Software Inc. *Statistica (Data Analysis Software System), Version 13.*; 2017.
 27. Łomnicki A. *Wprowadzenie Do Statystyki Dla Przyrodników*. Wydawnictwo Naukowe PWN; 2014.
 28. Bhabhor M, Vidja K, Bhandari P, Dodhia S, Kathrotia R, Joshi V. A comparative study of visual reaction time in table tennis players and healthy controls. *Indian J Physiol Pharmacol.* 2013;57:439-442.
 29. Gursay R. Sex Differences in Relations of Muscle Power, Lung Function, and Reaction Time in Athletes. *Percept Mot Skills.* 2010;110(3):714-720. doi:10.2466/pms.110.3.714-720
 30. Shejwal K, Kumar N. Comparison of Simple Reaction Time between Volleyball and Football Playing Collegiate Athletes. Published online February 1, 2020.
 31. Akpinar S, Devrilmez E, Kirazci S. Coincidence-anticipation timing requirements are different in racket sports. *Percept Mot Skills.* 2012;115(2):581-593. doi:10.2466/30.25.27.PMS.115.5.581-593
 32. Marmeleira J, Melo F, Tlemcani M, Fernandes J. Tennis Playing is Related to Psychomotor Speed in Older Drivers. *Percept Mot Skills.* 2013;117(2):457-469. doi:10.2466/25.10.PMS.117x20z9
 33. Tønnessen E, Haugen T, Shalfawi SAI. Reaction time aspects of elite sprinters in athletic world championships. *J Strength Cond Res.* 2013;27(4):885-892. doi:10.1519/JSC.0b013e31826520e3
 34. Nikam LH, Gadkari JV. Effect of age, gender and body mass index on visual and auditory reaction times in Indian population. *Indian J Physiol Pharmacol.* 2012;56(1):94-99.
 35. Jha RK, Thapa S, Kasti R, Nepal O. Influence of Body Mass Index, Handedness and Gender on Ruler Drop Method Reaction Time among Adults. *J Nepal Health Res Counc.* 2020;18(1):108-111. doi:10.33314/jnhrc.v18i1.2545
 36. Skurvydas A, Gutnik B, Zuoza AK, Nash D, Zuoziene IJ, Mickeviciene D. Relationship between simple reaction time and body mass index. *Homo.* 2009;60(1):77-85. doi:10.1016/j.jchb.2008.06.006
 37. Bell EC, Willson MC, Wilman AH, Dave S, Silverstone PH. Males and females differ in brain activation during cognitive tasks. *Neuroimage.* 2006 1;30(2):529-38. doi: 10.1016/j.neuroimage.2005.09.049. Epub 2005 Nov 2.
 38. Speck O, Ernst T, Braun J, Koch C, Miller E, Chang L. Gender differences in the functional organization of the brain for working memory. *Neuroreport.* 2000 3;11(11):2581-5. doi: 10.1097/00001756-200008030-

00046.
39. Bell EC, Willson MC, Wilman AH, Dave S, Silverstone PH. Males and females differ in brain activation during

cognitive tasks. *Neuroimage*. 2006 1;30(2):529-38. doi: 10.1016/j.neuroimage.2005.09.049.

Corresponding information:

Received: 06.04.2025.

Accepted: 14.06.2025.

Correspondence to: Lopuszanska-Dawid Monika

University: ul. Marymoncka 34, 00-968 Warszawa,
Poland

E-mail: monika.lopuszanska@awf.edu.pl