Original Article

doi: 10.16926/par.2025.13.09

Effort and reaction time in weightlifters, manual workers, and students – a pilot study

Agnieszka Berdowska [1ACDE], **Dominik Dusiński** [1BCD], **Katarzyna Bandurska** [1D], **Anatolii Tsos** [2D]

[1] Faculty of Science and Technology, Jan Dlugosz University in Częstochowa, Poland
[2] Institute of Physical Culture Science, Jan Dlugosz University in Częstochowa, Poland

Authors' Contribution: A – Study Design, B – Data Collection, C – Statistical Analysis, D – Manuscript Preparation, E – Funds Collection

Abstract: *Background:* Effort accompanies humans in practically every sphere of life. It can be divided into mental and physical effort. Physical effort is always initiated by some part of the mind, which signals the body or its parts to move or hold weight in a stationary position, thereby straining the muscles. The aim of this study was to evaluate the impact of effort specific to a given group on reaction time in weightlifters, manual workers, and physically active students. *Material and Methods:* The study involved 60 individuals divided into three groups: weightlifters (21.5±2.2 years), manual workers (21.8±1.6 years), and students (23.1±1.2 years). The S-10.2 reaction time meter by Alfa-Electronics was used for the research, measuring simple and choice reaction times. *Results:* In athletes, simple reaction time slightly worsened after effort (from an average of 0.2278 s before effort to 0.2316 s after effort), while choice reaction time improved (from 0.3442 s before effort to 0.3204 s after effort). Among workers, effort lengthened both simple reaction time (from 0.2279 s before effort to 0.2385 s after effort) and choice reaction time (from 0.3169 s before effort to 0.3456 s after effort). However, for students, reaction times were unaffected by effort. *Conclusions:* It can be concluded that effort influences reaction time, but the type, duration, and level of training of the individuals are important. Effort associated with sports improved reaction time among weightlifters, while effort related to physical labor in a production plant extended reaction times. No correlation was observed between age and reaction time in the analyzed group. Physical activity seems to reduce gender differences in reaction time.

Keywords: effort; simple reaction time; choice reaction time; weightlifters; manual workers

Corresponding author: Agnieszka Berdowska, email: a.berdowska@ujd.edu.pl

Recevied: 20.11.2024; Accepted: 30.12.2024; Published online: 8.01.2025

Citation: Berdowska A, Dusiński D, Bandurska K, Tsos A. Effort and reaction time in weightlifters, manual workers, and students – a pilot study. Phys Act Rev 2025; 13(1): 97-105. doi: 10.16926/par.2025.13.09

INTRODUCTION

Effort is a constant companion to humans and an indispensable element of performed activities. It relates to both physical and mental work. Physical or muscular effort can be defined as the work of skeletal muscles along with the associated energy transformations within the body. Motor effort is always initiated by some area of the mind, signaling the movement of the body or its parts, or maintaining weight in a stationary position, thereby exhausting the muscles. With the ongoing development of technology replacing human movements in work with machines, mental (cognitive) effort is increasing. Mental effort involves processes that may not require human movement but rather focus on monitoring and supervision (such as signaling machines) and assimilating, memorizing, and making accurate decisions based on incoming information [1]. Effort affects individuals differently, depending largely on personal predispositions and training [2]. Performing effort leads to fatigue, a temporary and reversible state of reduced work capacity occurring during physical or mental exertion. Fatigue decreases work efficiency and extends the time needed to respond to external stimuli [3]. The measure that evaluates the intake of information by a person is reaction time (RT), where a motor response is accompanied by the presented stimulus. Reaction time is defined as the period that elapses from the moment a signal appears to the moment a response is made to it [4]. The term "reaction time" was first introduced by Austrian physiologist Sigmund Exner in 1873, who described it as the time required to respond to a stimulus with a deliberate reaction. RT comprises five components: initial receptor activation, the emission of arousal in the central nervous system, signal transmission through the central nervous system and motor impulse preparation, signal flow from the central nervous system to muscles, and muscle excitation initiating movement [5,6]. RT serves as a good indicator of sensory-motor coordination and human efficiency. RT's duration in response to specific situations significantly affects human life, with practical implications: a fast RT may yield rewards (e.g., in sports), while a slow RT may lead to severe consequences (e.g., traffic safety or workplace accidents) [5–9]. Different types of experiments measure reaction time. Simple reaction time occurs when a single factor triggers a response [4,10]. The varied length of RT may correlate with the training of specific senses [10]. Additionally, as stimulus intensity increases, reaction speed rises, particularly in the initial phase, but continuous intensification may have less impact. Background contrast also plays a crucial role, for example, higher contrast in light stimuli can shorten RT [11]. Choice reaction time involves reacting to more than one stimulus and providing different responses for each stimulus [4,10]. As the number of choices increases, RT becomes longer. Moreover, RT may change if the significance of signals and the likelihood of their occurrence are not the same for all stimuli. Paying more attention to not all factors may lead to missing or deliberately ignoring less significant signals, which can result in prolonged RT. Various factors can influence RT, not only those related to the properties of the stimulus itself, but also those related to the individual, such as fatigue or experience [12]. Studies have shown that men generally have shorter RTs than women [13–15]. It has also been found, that the average RTs decrease significantly from childhood to adolescence before gradually increasing with age [13,16–18]. Furthermore, physically active individuals tend to have shorter RTs than inactive individuals [5,6,19–21].

This study aimed to examine the impact of effort specific to different groups on RT in weightlifters, manual workers, and physically active students. It also intended to address the following questions:

1. Does effort have a different impact on RT across the analyzed groups, and does the training level of the participants matter?
2. Is choice reaction time significantly longer than simple reaction time?
3. Does age influence RT in young adults?
4. Do RT gender differences exist among physically active young people?

Answers to these questions will enhance our understanding of factors affecting RT duration in young individuals, offering practical applications in sports and occupational physiology.

MATERIAL AND METHODS

Study Group

The study included healthy individuals aged 18–26 years, not currently taking medications or suffering from color vision disorders. Sixty participants were divided into three groups of 20 each. The first group comprised weightlifters (average age 21.5±2.2 years, 6 women, 14 men) with at least two years of training experience. Testing occurred during weightlifting competitions. The second group included manual workers from an automotive parts manufacturing plant (average age 21.8±1.6 years, 6 women, 14 men), working eight-hour shifts. The third group consisted of physical education students (average age 23.1±1.2 years, 7 women, 13 men) participating in academic sessions lasting 135 minutes.

Characteristics of the effort performed in the respective groups

A group of athletes – the competitors took part in the Olympic biathlon, which includes the snatch and clean and jerk. The snatch involved lifting the barbell overhead in one continuous motion. The clean and jerk had two phases: moving the barbell to the shoulders and then overhead. Each weightlifter had three attempts at both the snatch and the clean and jerk. Each attempt was preceded by a two-minute rest. This sport is dominated by anaerobic exercise and is highly intense.

A group of workers – manual work lasted 8 hours with a single 30-minute break after four hours of work. The task of the employees included in the study was to select and pack components from the automotive industry. Each time, the employee inspected one part, mainly for surface defects and deformations. This work is characterized by high monotony. Both physical effort (moving boxes with components) and mental effort (constant visual assessment of the inspected parts) can be observed in this job.

A group of students – the students attended and, as far as possible, actively participated in 135-minute-long academic sessions without a break. During the classes, the students remained in a seated position. The effort of this group was exclusively mental.

Equipment

The study was conducted using the S-10.2 reaction time meter (Alfa-Electronics, Poland). The device consists of a central unit, a signaling device, and buttons for recording reactions. It allows for RT measurements to be taken according to a predefined program.

Study protocol

Simple reaction time test: the participant was instructed to respond as quickly as possible by pressing a button when a light stimulus appeared on the meter's signal emitter. The test was conducted without any misleading signals. During this trial, 30 light signals were presented at varying frequencies.

Choice reaction time test: the participant was instructed to press a button held in the right hand when a green light appeared on the signal emitter and to press a button held in the left hand when a yellow light appeared. Additionally, a red light served as a misleading factor, requiring no response from the participant. A total of 30 stimuli appeared, displayed at varying frequencies.

The tests for each group were conducted in their respective work environments under natural daylight conditions. For each participant, reaction time measurements were taken twice on the same day – the first time before effort and the second time after effort: in the group of athletes measurements were taken immediately before the competition and directly after completing the effort associated with participating in the competition; in the group of workers measurements were taken before starting their work shift and directly after completing their shift; in the group of students measurements were taken before the start of classes and after 135 minutes of lessons. The participants remained seated throughout the test, and the signal emitter was placed on a desk in front of them, ensuring it was well within their field of vision. Each participant first completed the simple reaction time test, followed by the choice reaction time test.

Statistical analysis

A statistical analysis of the obtained measurement results was conducted. The normality of the data was assessed using the Shapiro-Wilk test. The homogeneity of variances was verified using the Levene test. For further analysis, a paired t-test was used for related variables, and ANOVA was applied for unrelated variables. Correlations were evaluated using Pearson's coefficient. A p-value of < 0.05 was considered statistically significant. All statistical analyses were performed using STATISTICA 13.0 software (StatSoft, Poland).

RESULTS

Figure 1 illustrates the results of simple reaction times before and after exertion in the studied groups. The results obtained by athletes, manual workers, and students before exertion did not differ significantly in statistical terms ($F=0.58$; $p=0.563$). The differences in mean values between the groups were on the order of thousandths of a second.

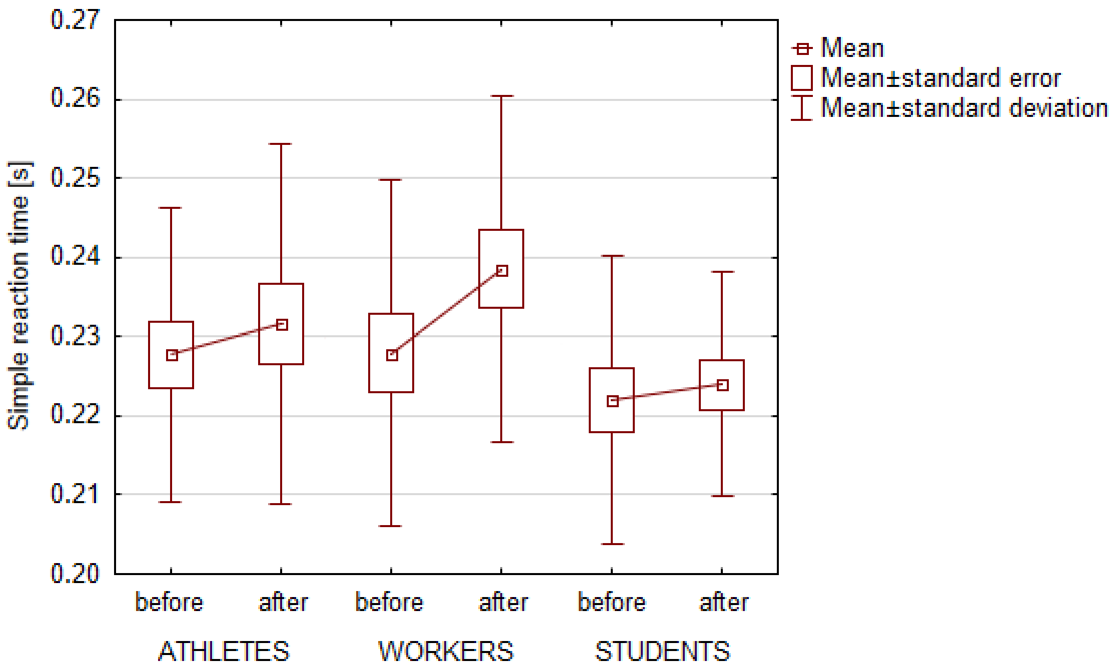

Figure 1. Simple reaction times in the studied groups before and after exertion.

Table 1. Mean simple and choice reaction times in the studied groups before and after exertion.

Reaction	Relation to effort	Group								
		Athletes			Workers			Students		
		time [s]	t	p	time [s]	t	p	time [s]	t	p
simple	before	0.2278	-1.97	0.064	0.2279	-2.83	0.011*	0.2220	-0.61	0.547
	after	0.2316			0.2385			0.2240		
choice	before	0.3442	2.98	0.007*	0.3169	-4.56	<0.001*	0.3343	0.04	0.966
	after	0.3204			0.3456			0.3340		

t: results of paired t-test; p: significance level; * statistically significant.

After exertion, an increase in reaction time was observed in all groups (Table 1), with the most pronounced deterioration occurring in the worker group, and this difference was statistically significant. In the other two groups, the changes were not statistically significant. When analyzing the differences in simple reaction times between groups after exertion, a statistically significant difference was found only between the worker and student groups (F=6.12; p = 0.017).

Figure 2 illustrates the results of choice reaction times before and after exertion in the studied groups. Similarly to the simple reaction time, the choice reaction time also did not differ significantly between the studied groups prior to exertion (F=2.41; p=0.099). Post-exertion, a statistically significant shortening of choice reaction time was observed in athletes, while a statistically significant prolongation was noted in the worker group. In contrast, the reaction time in the student group changed only minimally, without statistical significance (Table 1). When analyzing the differences in choice reaction times between groups after exertion, a statistically significant difference was found only between the athlete and worker groups (F=4.39; p=0.043).

In all studied groups, the choice reaction time was significantly longer compared to the simple reaction time, both before and after exertion (Table 2).

No statistically significant correlation was found between the age of the participants and either simple or choice reaction time in any of the studied groups, both for times before and after exertion.

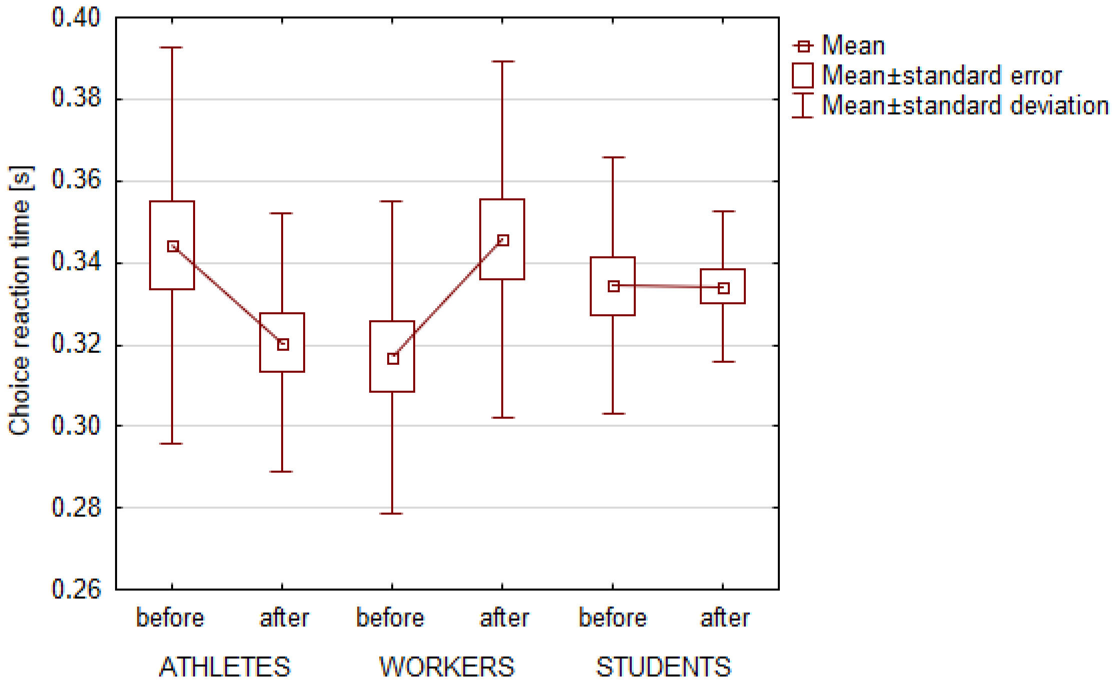

Figure 2. Choice reaction time in the studied groups before and after exertion.

Table 2. Comparison of simple and choice reaction times in the studied groups.

Relation to effort	Statistical significance	Group		
		Athletes	Workers	Students
before	t	-10.799	-11.426	-14.030
	p	<0.001*	<0.001*	<0.001*
after	t	-12.293	-12.040	-21.400
	p	<0.001*	<0.001*	<0.001*

t: results of paired t-test; p: significance level; * statistically significant.

Differences in reaction times depending on gender were also analyzed. A statistically significant difference was found only in the case of simple reaction times among students before exertion (women: 0.2111 s; men: 0.2279 s; F=4.56; p=0.047) and choice reaction times among workers before exertion (women: 0.3483 s; men: 0.3034 s; F=8.00; p=0.011), while in all other cases, the differences were not statistically significant.

DISCUSSION

This study examined how simple and choice reaction times change in different groups of individuals performing distinct types of physical effort. The study included athletes training in weightlifting, manual workers, and students. In the simple reaction test, the participant was required to respond as quickly as possible to a stimulus. In the choice reaction test, two stimuli were presented, requiring different responses, which significantly prolonged the reaction times. Our study found that the reaction times for the choice reaction test were significantly longer compared to those for the simple reaction test in all examined groups. In the case of the choice reaction, additional time is needed for signal analysis and decision-making. The results of the study showed that effort does not impact each group in the same way.

In our study, physical effort had the most positive effect on the athlete group. Although they achieved slightly worse results in the simple reaction test after exertion, their performance in the choice reaction time test significantly improved. Exercise increases the levels of brain neurotransmitters such as catecholamines, serotonin, and dopamine [22], which in turn affects the activation of the nervous system and thus reaction times [23]. Previous studies on the effects of muscle fatigue on RT have led to diverse conclusions. For instance, it has been shown that low-intensity exercise may shorten RT, as observed in cycling [19,20] or running [6,21], likely due to increased attention. However, once a certain duration or intensity of exercise is surpassed, RT tends to lengthen, which may be due to a decrease in cognitive performance [24]. In contrast, a study by Le Mansec et al. found that muscle effort involving repeated biceps contractions did not significantly alter simple RT [3].

The literature contains reports that individuals who engage in sports have faster RT compared to those leading a less active lifestyle [25-28]. This may be due to the need to make quick decisions in repetitive sports situations [10,29], which results in shorter processing times in the central nervous system over time [30], better concentration and alertness, improved muscle coordination, and ultimately better performance in tasks requiring speed and accuracy [31]. In our study, we did not find significant differences between athletes and the other groups in reaction times measured before exertion. This may be due to the fact that the other two groups also exhibited some physical activity: the workers due to their job and the students due to the nature of their studies. Only physical effort led to a difference in reaction times between athletes, who represented the most trained group, and the workers, who were the least trained group in this study.

The workers were the only group in this study in which both simple and choice reaction times significantly worsened. Although the physical effort performed by this group was not very intense, the long duration of work, along with the need for constant concentration when checking individual components for defects, could have contributed to general physical fatigue over the course of an 8-hour workday. Additionally, the monotonous nature of the work could have caused significant emotional distress. Monotony leads to a decrease in attention, resulting in reduced work efficiency, increased errors, and longer reaction times. Mental fatigue is a factor that contributes to longer reaction times [12,32], affecting attention and, thus, the processing of stimulus information and the initiation of motor responses [3].

The next group studied consisted of students participating in classes. In this group, the intellectual effort associated with attending university classes essentially did not affect either simple or choice reaction times. Their exertion was primarily mental, involving listening, focusing, and answering or asking questions, without physical fatigue. The effort in this group was primarily mental and was mainly based on focusing, listening to the lecturer, responding to their questions, or asking questions. This group did not exhibit physical fatigue, and their emotional state appeared to be similar both before and after the effort. Previously, Le Mansec et al. demonstrated that a 14-minute intense mental effort involving solving mathematical tasks did not significantly change reaction time [3]. In our study, mental exertion was less intense but longer in duration (135 minutes).

An important factor influencing RT is the age of the participant. RT is longer in childhood, then shortens during adolescence until the late 20s, after which it increases again in older age [17]. In this study, no correlation was found between age and either simple or choice reaction time. This is likely because the study participants were young adults within a narrow age range, preventing the age effect from manifesting in reaction times.

There are studies suggesting that RT is shorter in men compared to women (e.g., in sedentary medical students [5]). Gender differences have been explained by the delay between stimulus presentation and the onset of muscle contraction, with motor responses in men being relatively stronger than in women [5,33]. In our study, such a relationship was observed only in the case of the choice reaction time before the effort in the group of employees. However, in the case of simple reaction time before the effort in the student group, the opposite was found, with women showing shorter reaction times. For all other reaction times measured, no gender differences were observed. Similarly, Żak et al. [34] found no difference in RT between genders in young cyclist athletes, and Jain et al. found no differences in RT between genders among regularly trained first-year medical students [5]. It seems, therefore, that a high level of physical activity may diminish gender differences in RT.

CONCLUSION

Based on the conducted research, the following conclusions were drawn:

1. Exertion affects reaction times, with its impact depending on the type of exertion, its duration, and the fitness level of the participants. Beneficial effects were observed in weightlifting athletes, whose choice reaction times improved post-exertion. Conversely, prolonged physical and mental exertion led to longer reaction times among manual labor workers. In contrast, intellectual exertion in physically active students did not significantly affect their reaction time.
2. The hypothesis was confirmed that choice reaction times are significantly longer compared to simple reaction times in all the studied groups.
3. No correlation was found between age and RT in the young adult group analyzed.
4. Physical activity appears to mitigate gender differences in RT.

Funding Statement: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

REFERENCES

1. Massin O. The nature and difficulty of physical efforts. Synthese 2024; 203: 177. doi: 10.1007/s11229-024-04572-5.
2. Blazek D, Pisz A, Hojka V, Uhlir P, Kolinger D, Zajac A, Stastny P. The bench press prime mover muscles firing frequency changes according to sticking region during maximal and submaximal effort. Phys Act Rev 2024; 12(1): 150-160. doi: 10.16926/par.2024.12.14
3. Le Mansec Y, Dorel S, Nordez A, Jubeau M. Is reaction time altered by mental or physical exertion? Eur J Appl Physiol 2019; 119(6): 1323–1335. doi: 10.1007/s00421-019-04124-7.

4. Balkó Š, Borysiuk Z, Šimonek J. The influence of different performance level of fencers on simple and choice reaction time. Braz J Kinanthrop Hum Perform 2016; 18(4): 391–400. doi: 10.5007/1980-0037.2016v18n4p391.
5. Jain A, Bansal R, Kumar A, Singh KD. A comparative study of visual and auditory reaction times on the basis of gender and physical activity levels of medical first year students. Int J Appl Basic Med Res 2015; 5: 124–127. doi: 10.4103/2229-516X.157168.
6. Malhotra V, Goel N, Ushadhar U, Tripathi Y, Garg R. Exercise and reaction times. J Evol Med Dent Sci 2015; 4(25): 4277–4281, doi: 10.14260/jemds/2015/618.
7. Zeydabadi A, Askari J, Vakili M, Mirmohammadi SJ, Ghovveh MA, Mehrparvar AH. The effect of industrial noise exposure on attention, reaction time, and memory. Int Arch Occup Environ Health 2019; 92(1): 111–116. doi: 10.1007/s00420-018-1361-0.
8. Dolo K, Grgantov Z, Kuvacic G. Reliability and usefulness of the reaction speed test in young female volleyball players. Phys Act Rev 2022; 10(1): 77-85. doi: 10.16926/par.2022.10.09.
9. Góra T, Mosler D, Ortenburger D, Wąsik J. Sex differences in utilizing effective mass among taekwon-do athletes performing turning and side kick. Phys Act Rev 2024; 12(2): 78-85. doi: 10.16926/par.2024.12.23.
10. Vasilica G, Mitrache G, Paunescu M, Predoiu R. The decision time, the simple and the discrimination reaction time in elite romanian junior tennis players. Procedia Soc Behav Sci 2015; 190: 539–544. doi: 10.1016/j.sbspro.2015.05.040.
11. Steinman Y, Groen E, Frings-Dresen MHW. Hypoxia impairs reaction time but not response accuracy in a visual choice reaction task. Appl Ergon 2023; 113: 104079. doi: 10.1016/j.apergo.2023.104079.
12. Chander H, McCrory A, Chandler SJ, Freeny S, Griffith A, Burch R, et al. Noise interference impacts simple and choice response times during a lower extremity cognitive–motor task. Clin Transl Neurosci 2023; 7(1): 4. doi: 10.3390/ctn7010004.
13. Dykiert D, Der G, Starr JM, Deary IJ. Sex differences in reaction time mean and intraindividual variability across the life span. Dev Psychol 2012; 48: 1262–1276. doi: 10.1037/a0027550.
14. Shelton J, Kumar GP. Comparison between auditory and visual simple reaction times. Neurosci Med 2010; 1: 30–32. doi: 10.4236/nm.2010.11004.
15. Ghisletta P, Renaud O, Fagot D, Lecerf T, de Ribaupierre A. Age and sex differences in intra-individual variability in a simple reaction time task. Int J Behav Dev 2017; 42: 294–299. doi: 10.1177/0165025417739179.
16. Bucsuházy K, Semela M. Case Study: Reaction time of children according to age. Procedia Eng 2017; 187: 408–413. doi: 10.1016/j.proeng.2017.04.393.
17. Der G, Deary IJ. Age and sex differences in reaction time in adulthood: Results from the United Kingdom Health and Lifestyle Survey. Psychol Aging 2006; 21(1): 62–73. doi: 10.1037/0882-7974.21.1.62.
18. Deary IJ, Der G. Reaction time, age, and cognitive ability: longitudinal findings from age 16 to 63 years in representative population samples. Aging Neuropsychol Cogn 2005; 12: 187–215. doi: 10.1080/13825580590969235.
19. Davranche K, Burle B, Audiffren M, Hasbroucq T. Physical exercise facilitates motor processes in simple reaction time performance: an electromyographic analysis. Neurosci Lett 2006; 396(1): 54–56. doi: 10.1016/j.neulet.2005.11.008.
20. Guzmán JF, López-García J. Acute effects of exercise and active video games on adults reaction time and perceived exertion. Eur J Sport Sci 2016; 16(8): 1197–203. doi: 10.1080/17461391.2016.1186744.
21. Collardeau M, Brisswalter J, Audiffren M. Effects of a prolonged run on simple reaction time of well-trained runners. Percept Mot Skills 2001; 93(3): 679–689. doi: 10.2466/pms.2001.93.3.679.
22. Meeusen R, Watson P, Hasegawa H, Roelands B, Piacentini MF. Central fatigue: the serotonin hypothesis and beyond. Sports Med 2006; 36: 881–909. doi: 10.2165/00007256-200636100-00006.
23. Brisswalter J, Collardeau N, Arcelin R. Effects of acute physical exercise characteristics on cognitive performance. Sports Med 2002; 32(9): 555–566. doi: 10.2165/00007256-200232090-00002.
24. Chmura J, Nazar K, Kaciuba-Uscilko H. Choice reaction time during graded exercise in relation to blood lactate and plasma catecholamines thresholds. Int J Sports Med 1994; 15(4): 172–176. doi: 10.1055/s-2007-1021042.
25. Welford AT. Choice reaction time: Basic concepts reaction times. Academic Press: New York 1980; 73–128.
26. Kaur P, Paul M, Sandhu JS. Auditory and visual reaction time in athletes, healthy controls, and patients of type I diabetes mellitus: A comparative study. Int J Diabetes Dev Ctries 2006; 26: 112–5. doi: 10.4103/0973-3930.32170.

27. Nakamoto H, Mori S. Sport-specific decision-making in a Go/NoGo reaction task: Difference among nonathletes and baseball and basketball players. Percept Mot Skills 2008; 106: 163–70. doi: 10.2466/pms.106.1.163-170.
28. Ghuntla TP, Mehta HB, Gokhale PA, Shah CJ. A comparative study of visual reaction time in basketball players and healthy controls. Natl J Integr Res Med 2012; 3: 49–51. doi: 10.70284/njirm.v3i1.1966.
29. Kuan YM, Zuhairi NA, Manan FA, Knight VF, Omar R. Visual reaction time and visual anticipation time between athletes and non-athletes. Malays J Public Health Med 2018; 1, 135–141.
30. Spirduso WW. Reaction and movement time as a function of age and physical activity level. J Gerontol 1975; 30: 435–40. doi: 10.1093/geronj/30.4.435.
31. Gavkare AM, Nanaware NL, Surdi AD. Auditory reaction time, visual reaction time and whole body reaction time in athletes. Ind Med Gaz 2013; 6: 214–219.
32. Langner R, Steinborn MB, Chatterjee A, Sturm W, Willmes K. Mental fatigue and temporal preparation in simple reaction-time performance. Acta Psychol 2010; 133(1): 64–72. doi: 10.1016/j.actpsy.2009.10 .001.
33. Silverman IW. Sex differences in simple visual re-action time: A historical meta-analysis (Sports Events) Sex Roles 2006; 54: 57–69. doi: 10.1007/s11199-006-8869-6.
34. Żak M, Mikrut G, Sobota G. Measurement of simple reaction time of the cyclist in the laboratory and natural environment condition. Sensors 2023; 23(8): 3898. doi: 10.3390/s23083898.