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A comparison of reaction times of boys and girls aged 10-11 and 14-15 years

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Introduction. Pubescence is a life stage with the most turbulent progression of sensorimotor abilities during the transformation of a child into an adult. Differences in all sensorimotor abilities between boys and girls are become significant at this age. The progression of reaction abilities in girls decreases at this age (girls achieve peak values around the age of 15), while the reaction abilities in boys keep improving into adolescence. Younger children compared to adults and older children show a reduced ability to perform one or more tasks concurrently with a movement task. Aim of Study. The purpose of the study was to determine the time of complex reaction of the lower limbs of children. Moreover, a relationship between reaction time, age and gender was also found. Material and Methods. The research group included 81 primary school students aged 10-15 years. Subjects were divided into four groups according to age and gender (Group 1 – 9.8 to 10.8-year-old girls, n = 20; Group 2 – 10.0 to 10.7-year-old boys, n = 19; Group 3 – 14.3 to 15.3-year-old girls, n = 21; and Group 4 – 14.2 to 15.2-year-old boys, n = 21). The measurements were carried out using the FiTRO Agility Check test. A two-way ANOVA revealed statistically significant differences between the groups. The significance level was adjusted to 0.05. Tukey's post-hoc test was used to determine differences between pairs of groups. Results. There are significant differences between the boys and girls aged 14-15 years. Other differences between boys and girls aged 10-11 years were not statistically significant, however, girls performed with slightly shorter reaction times. Conclusions. The research showed a significant relationship between age and complex reaction speed in the age group of 14-15 of boys and girls. This study helps to prove that boys do not have shorter complex reaction times than girls aged 10-11 years.

KEY WORDS: FiTRO Agility Check, complex reaction time, pubescence, age.

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What is already known on this topic?
Research shows that reaction time is, to a large extent, a genetically affected sensorimotor ability that can be improved by training. Reaction time depends predominantly on individual attributes of the nervous and muscle systems. Simple reaction time and movement time to a specific stimulus are significantly shorter than multiple choice reaction time. Reaction time is shorter in childhood, approximately until the age of 15 years of age, and then it slowly deteriorates.

Introduction

Physical activity of teenagers is a widely discussed issue in modern society [1]. The high level of physical inactivity and its consequences, lack of active involvement in sport, a sedentary lifestyle, inadequate nutrition, spending long hours in social networks as well as many other determinants have negative effects on the majority of the teenage population. Lifestyle diseases such as obesity, vertebral disorders, cardiovascular

diseases and others are visible manifestations of these degenerative effects [2]. All these negative factors also affect teenagers' psychomotor performance and thus their reaction and movement speed [3].

Early school age starts with the first school attendance (6-7 years) and ends with the onset of puberty (11 years for girls, 12 years for boys). This period is characterized by a high level of spontaneous physical activity. Late school age (11-15 years) is known as the period of pubescence divided into two main phases: pre-puberty and puberty [4]. Pubescence is the most turbulent phase of progression of sensorimotor abilities in the child to adult transformation. Pre-puberty is characterized by accelerated growth and the discovery of the first secondary sexual characteristics (turbulent period). Puberty is known as the phase of relative serenity. During pubescence there is a strong, albeit uneven, progression cane be observed, which affects sensorimotor skills and coordination of all individuals. Somatic disproportionality and uncoordinated characteristics of physical movements increase with accelerated growth. Bone ossification and growth of internal organs continue, while the motor center in the brain matures. Effects of puberty vary among individuals. Physical activity distinctly reduces negative effects [5]. Differences in performance in all sensorimotor abilities between boys and girls at this age become visible [6]. Girls also improve their performance, albeit with slower progress. While the speed abilities of boys still improve in adolescence, girls achieve the peak of theirs around the age of 15 [7].

Speed is the ability to overcome a distance in the shortest time possible. It is affected by reaction time as well as movement time. Reaction time is the elapsed time from the signal to the first movements of body. Movement time is the time elapsed from the initial movement to the completion of the action [1].

Reaction time and reaction speed testing have been subject to numerous experimental research studies [8-11]. Responses to stimuli are more complex than reflexes and require the involvement of higher brain functions. As the reaction receptor detects changes, sensory neurons send information to the central nervous system, and motor neurons send information to effectors, e.g. skeletal muscle [12]. Reaction time depends on the speed of the sensory-motor loop, which involves initial stimulus detection, afferent neural pathways, central neural system response generation, efferent neural pathways and final effector performance [13]. Shorter reaction time means better creativity of the central nervous system [3].

We can distinguish between simple reaction time, also referred to as reaction speed, and multiple choice reaction time [2]. Simple reaction time is the interval between the appearance of the stimulus and the beginning of response. Multiple choice reaction time involves stimulus identification as well as selection of a response to various stimuli. In this case, reaction time indicates the effectiveness of decision-making [11]. Reaction time consists of psychomotor reactivity, which is genetically determined, while peripheral motor composition is influenced by training [14]. Movement time for simple reactions reaches its minimum around the mid-teens and remains at that level usually until 20-25 years of age [2]. Simple reaction time and movement time to a specific stimulus is significantly shorter than multiple-choice reaction times [7].

The most sensitive period of development of speed abilities, and therefore reaction speed, falls between 10 to 14 years, and is closely related to coordination abilities [15]. The subsequent progression of reaction speed in pubescence and early adulthood is associated with the development of strength, improvement of techniques and anaerobic capacity [5]. The period of pubescence lasts until reaching sexual maturity, i.e. full reproductive capacity and completion of growth. Due to individual differences between the developing children we are not able to precisely determine the boundaries of pubescence.

Agility and reaction speed significantly affect performance. Although they are most genetically influenced of the sensorimotor skills, they can be improved by training [16]. Reaction speed and movement speed are essential not only in most sports, but they also have a considerable impact on everyday life (e.g. driving, dodging a falling object). The reaction speed of lower limbs is often more important than reaction of the upper limbs. Reaction time is influenced by many determinants such as age, gender, stimulus type and intensity, motivation, attention, concentration, and current physical and psychical condition [6, 8-10, 16]. Several studies have dealt with the problem of reaction time of children, especially with regard to the reaction of the upper limbs (e.g. Reactometer tests [9, 17], Nelson test [18], Groningen Reaction Time Test [19]), but there is still a need for more precise measurement tools. One of such possibilities is a rarely described, special reaction time test called the FiTRO Agility Check, which

could provide useful information on the level, changes and progression of reaction time of the lower limbs at different periods of pubescence.

Aim of Study

The purpose of the study was to determine the time of complex reaction of the lower limbs in children. Moreover, the study also attempted to find out relationships, reaction time, age and gender.

Material and Methods

Subjects

The research sample included 81 primary school students from Prague aged 10-15 years. The subjects were divided into four groups according to their age and gender: Group 1 – 9.8 to 10.8 year-old girls, n = 20; Group 2 – 10.0 to 10.7 year-old boys, n = 19; Group 3 – 14.3 to 15.3 year-old girls, n = 21; and Group 4 – 14.2 to 15.2 year-old boys, n = 21. Data on subjects' body mass and body weight is shown in Table 1. The students took part in school PE classes twice a week (2 x 45 min).

Table 1. Students' body mass and body height with regard to age and gender

Age	Boys M ± SD; min. – max			Girls M ± SD; min. – max		
		Body height (cm)	Body mass (kg)		Body height (cm)	Body mass (kg)
10-11 years	N = 19	144.1 ± 6.85 (132 – 168)	34.73 ± 6.23 (27 – 54)	N = 20	146 ± 2.62 (142 – 151)	32.2 ± 3.21 (28 – 40)
14-15 years	N = 21	169 ± 7.21 (160 – 185)	68 ± 9.57 (47 – 88)	N = 21	169.9 ± 5.0 (160 – 181)	55.9 ± 5.83 (45 – 68)

Procedures

The tests were conducted in a selected school in a well-lit, soundproof room at the same time of the day, i.e. in the morning, to avoid tiredness. All subjects were healthy, with no signs of disturbances in their physical development. They were introduced to the method of implementation and evaluation tests. After a standard warm-up a reaction test was carried out. The research protocol was approved by the Ethics Committee FTVS UK Nr. 0153/2012.

The research was conducted by measuring the sensorimotor reaction time of the lower limbs using the FiTRO Agility Check. The test consisted of the stages of stimulus perception, decision making and movement execution, and thus provided information on complex sensorimotor reaction times. During the FiTRO Agility Test the participants had to touch as fast as possible with either the left or the right foot, one of four square mats located in four corners outside a 50 x 50 cm square. The subjects stepped on the mats following the appearance of a stimulus in one of the corners of the PC screen (a red circle on a white background). The stimuli were randomly generated in a predetermined time period (1500 – 3000 ms). The test measured total reaction time and reaction time in each stepping movement direction [11].

Three different protocols were developed, each consisting of 60 stimuli (15 in each direction). Thus the possibility of remembering the localization of stimuli was excluded. The mean of the best eight reaction times in each direction proved to be the most reliable parameter of the test with a random generation of their localization [21]. Each individual completed all three protocols. The protocol, in which the best overall time was achieved, was taken as the test result. The authors of the test [11] describe in detail the specific methodology for testing and evaluation of results.

Statistical analysis

The obtained results were subjected to statistical analysis. Arithmetic means, minimum and maximum values and standard deviations were calculated. To assess differences between individual pairs of groups a Two Way ANOVA was used with Tukey's post-hoc test. The Origin Pro 8.1 software package (OriginLab Corporation, Northampton, MA, USA) was used in statistical analysis. The results were presented on a graph and in the tables.

Results

In the reaction test each group reached the following mean values: Group 2 (boys aged 10-11 years): 798 ± 48.5 ms; Group 1 (girls aged 10-11 years): 785 ± 37.9 ms; Group 4 (boys aged 14-15 years): 592 ± 21.4 ms; Group 3 (girls aged 14-15 years): 629 ± 51.5 ms. The diversification of individuals in groups revealed minimum and maximum values. The resulting test values are shown in Table 2.

Table 2. Test results accounting for gender and age groups

Age	Boys M ± SD; min. – max		Girls M ± SD; min. – max		p
10-11 years	N = 19	798 ± 48.5 (694 – 882)	N = 20	785 ± 37.9 (668 – 836)	ns
14-15 years	N = 21	592 ± 21.4 (552 – 628)	N = 21	629 ± 51.5 (567 – 767)	*
p		**		**	

* $p \leq 0.05$; ** $p < 0.01$; ns – not significant

The comparison of boys and girls aged 10-11 years did not reveal a statistically significant difference in reaction times ($p = 0.7679$), although the girls had slightly better reaction time (13 ms). When comparing reaction times between boys and girls aged 14-15 years a significant difference was demonstrated ($p = 0.0272$), and the boys reached on average a shorter reaction time of 37 ms. The greatest statistical significance was found between the boys aged 10-11 and 14-15 years (Table 2). The reaction time of boys aged 14-15 years was about 206 ms shorter.

The test results revealed relationships between age and reaction time, which in students between 10-15 years decreased with age (Fig. 1). The coefficient of determination of the regression curve and measured values ($R^2 = 0.982$) shows a close relationship between age and reaction time in the period from 10 to 15 years of age. Accordingly, a logarithmic regression occurs with the mean reduction of complex reaction time of the lower limbs for approximately 5.7% per year in children between 10-15 years.

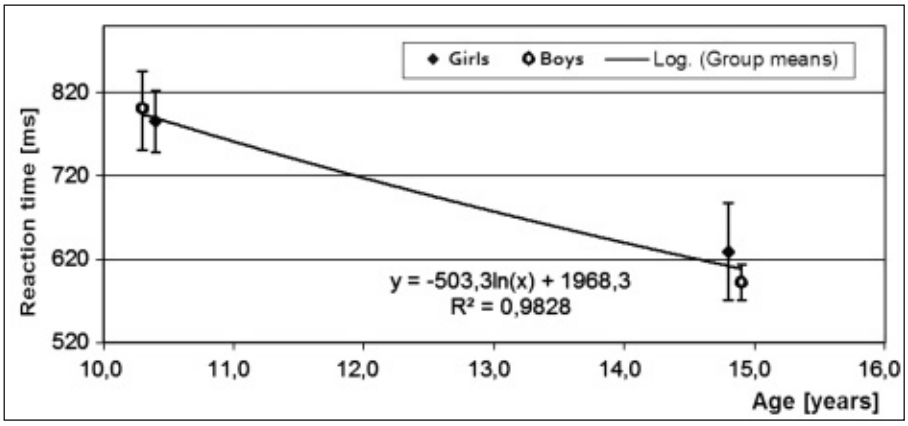

Figure 1. Mean reaction times and relationships between age and complex reaction times. R^2 denotes the coefficient of determination in goodness of fit evaluation

Discussion

This study aimed at determining complex sensorimotor reaction times of the lower limbs in boys and girls aged 10-15 years and at their inter-group comparison. Statistically significant ($p = 0.05$) differences were found in complex reaction times of the lower limbs between boys and girls aged 14-15 years and between mixed age groups of 10-11-year and 14-15-year olds. This confirms the observation of a less complex reaction in boys aged 14-15 years and older children.

The difference in reaction times between boys and girls aged 14-15 indicated a shorter complex reaction time in boys. The findings are consistent with many studies that show boys have generally a shorter reaction time than girls [8, 9, 22-24]. Standard deviation in the group of girls was less homogenous among the 14-15-year-olds, but the minimum values showed that some girls achieved similar results to boys.

On the other hand, the comparison of boys and girls aged 10 to 11 years revealed slightly shorter reaction times in girls. The comparison between the total number of girls ($n = 41$) and boys ($n = 40$) aged 10-15 years did not show a statistically significant correlation, although the boys had a slightly shorter reaction time. Silverman [25] found that differences between reaction times of men and women in the visual response decrease, due to the significant involvement of women in motor sports and "action sports". It is possible that this also happens in children, because one third of the studied girls took part in "action sports" (i.e., fitness boxing, taekwondo, jiu-jitsu, fencing or aerobics).

The comparison of age groups of subjects (10-11 years) and (14-15 years) revealed significantly shorter reaction times in the older children. These findings are consistent with results of studies indicating that younger children performed a wide variety of information-processing tasks more slowly than older children [26, 27]. Throughout childhood and adolescence, consistent age differences in processing speed can be observed [25].

The motor reflexes and reaction times in tasks involving decision

making (choice reaction times) take somewhat longer to mature [2]. Physiological and psychological maturation of the organism is one of the main reasons why older children display faster (shorter) reaction times than younger children. The reaction time of children, according to Fozard et al. [6], improves approximately until the age of 20, and, according to Abernethy [2], until the age of 25. Luchies et al. [28] reported that the age effect is more pronounced in complex reactions, and this was also confirmed by Deary & Dear [24]. Both tested groups had a similar level of homogeneity. Almost the same standard deviation values of reaction times between the age groups of 10-11 and 14-15 years may be explained by the specific test evaluation, which practically eliminated false responses. What is confirmed is the relationship between decreasing reaction time and increasing pubescent age between 10-15 years. The shorter reaction time with increasing age in pubescence may be affected by improving visual function and sport activities [29, 30]. Vänttinen et al. [31] claim that the total perceptual and motor abilities and the reaction times are improved with age (especially between 12 and 14 years) and with higher performance and anticipation levels. On the other hand, Ward et al. [32] did not confirm shorter reaction times in elite athletes compared to the average population. Our logarithmic regression tests in children between 10-15 years indicate that an average decrease of reaction time was approximately 5.7% per year.

It is probable that suitable training methods can improve complex reaction speeds (decrease reaction times) from 15 to 25% [33]. Schmidt & Wriesberg [34] state that an extreme amount of training as well as high performance and anticipation levels can automatically lead to faster reactions. Other important determinants of reaction time include activation, motivation, fatigue, distraction, training, tenacity of attention, concentration and stimulants [9, 27, 33, 35].

Compared with the agility standards [36] the average reaction times of children aged 10 to 11 years are below the standard average, while the reaction times of children aged 14-15 are concurrent. Brychta et al. [37] achieved similar results in a group of boys aged 10-11 years (816.3 ± 84.7 ms) when the reaction times revealed a slight difference (18 ms). The results can be helpful in talent identification, where the achieved results can be compared with the already developed standards for various age groups of children [11], in the process of differentiation of athletes groups with other requirements of legs agility.

Conclusion

The conducted tests proved that girls aged 10-11 years have a slightly shorter reaction time of the lower limbs than boys. The inter-gender comparison within the age group of 14-15-year-olds, revealed statistically significant differences in the time of reaction between boys and girls. Children aged 14-15 years have significantly shorter complex reaction times in the lower limbs than children aged 10 to 11 years, which is most probably due to their levels of physiological and psychological maturity.

What this study adds?

The application of the FiTRO Agility Check test reveals similarities between complex reaction time development of the lower limbs with age and other, simple or multiple, reaction time tests. The study shows that boys have similar reaction times to girls aged 10-11, but achieve shorter reaction times between the ages of 14-15 years.

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