Original Article

Relationship between reactive agility, cognitive abilities, and intelligence in adolescents

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Abstract

The work identifies differences in performance levels and the relationship between reactive agility, intelligence and cognitive abilities in adolescents (boys vs girls). The differences in performance levels were compared separately for boys and girls. The research was conducted at the grammar school, where 100 respondents were tested ($N_{b59} + N_{g41} = N_{100}$). To determine the level of variables, we used the Inborn Intelligence Test (TIP Test), the Cognitive Capability Test (Stroop test), the Reactive Agility Test (Y test). The results showed that statistically significant differences between boys and girls were found only in the case of reactive agility ($\text{sig} = 0.003 *$). We found higher values in boys than in girls, when assessing differences in cognitive abilities between the two genders, but not statistically significant ($\text{sig} = 0.447$). The correlation analysis did not confirm a statistically significant relationship between reaction agility and cognitive abilities ($\rho = -0.124$). There were no statistically significant relationship between these indicators in adolescents. In the case of finding the relationship between variables, we found dependence only in the case of intelligence and reactive agility ($r = 0.666$). We reached no statistically significant relationship between the variables ($\rho = -0.021$) when determining the relationship between intelligence and cognitive abilities. We note that there was a significant relationship between these indicators in adolescents ($r = 0.021$). In the case of the exclusion of motor functions (reactive agility), we did not observe the dependence of variables. We assume that in the non-sporting adolescent population these abilities are not sufficiently developed to justify their conditionality.

Keywords: change of direction, physical tests, correlation, relationship, adolescents,

Introduction

Agility is an essential component of sports performance in many sports, especially sports games and combat sports. Traditional definitions of agility say that agility involves the rate of change in the direction of movement of an athlete (Young et al, 2002; Sheppard & Young, 2006). A new understanding of agility involves two sub-components: the rate of change of direction of motion as well as cognitive factors. In the detailed definition of the concept of agility we still encounter the inconsistency of the authors. Some authors define agility as the ability to change the direction of movement of the whole body as well as to make rapid movements and change the direction of movement of limbs (Beachle, 1994). There is no broader view, especially in terms of the impact of cognitive processes and perception. Change of Direction (CODS) implemented at full speed, coordination of movement and sufficient technical-tactical quality are common athletic maneuvers of the player. Their assumption is a combination of physical (physiological), technical and tactical attributes in order to create some movement dominance over the opponent. Hojka et al (2016) emphasises the need to specify the CODS tests for different group of athletes like sub-elite or elite and according the needs of particular sport discipline. They also mentioned that sprinting and jumping tests are stronger than explosive strength and maximum strength tests. The research by Matlák, Tihanyi & Rácz (2016) was realized on 16 amateur football players. They were looking for the relationship between reactive agility and the change of direction of speed. There were found no significant correlation among variables measured of CODS, reactive agility and countermovement (CMJ) tests. There were also realized the newest studies where evaluated CODS as the pre-planned and non-planned (reactive) agility performance in 36 individual athletes and 34 team sportsathletes in different positions (Mackala et al, 2020). Team sports athletes proved stronger relations between sprint performance and change of direction speed (CODS) condition. The individual athletes' performance confirmed stronger correlation in reactive agility condition. The results of many studies (Horička et al, 2014; Little & Williams, 2005; Lockie et al, 2014) reiterate that planned and reactive agility are independent motor skills. This should also be taken into account in the diagnosis of agility. Agility tests should therefore include a cognitive and decision-making component (Sekulić et al, 2017). During the match they perform e.g. elite basketball players distance 991 m of high intensity moves, 40 to 60 maximum vertical jumps, and 50 to 60 changes in direction and speed (Spiteri, et al., 2014). The authors (Balčiunas et al, 2006) stress the importance of physical, especially strength, attributes. Making effective changes in direction with or without the ball often determines the player's performance in basketball (Delextrat et al., 2009). In the practice so far, we have often come to the conclusion that a player's ability to move quickly, change direction and speed of movement is limited solely by speed and speed-strength abilities, muscle fibre structure and overall genetic conditionality. The important role of perception has not been emphasized as a factor

that has a significant influence on the temporal characteristics of movement realization and thus on its overall quality (Šimonek et al, 2016). This view should also include cognitive skills in determining the level of agility and concerns only open skills. Open skills cannot be pre-planned, while closed skills such as predetermined running direction and speed, can be pre-planned and learned, and are performed automatically without the need to respond to an external stimulus (Sheppard & Young, 2006). It is precisely the level of cognition that Tenenbaum et al (1993) ranks among the primary factors influencing the player's decision-making process in sports games. In addition, the ability to extract accurate information based on the perception of opponents' movements and then in anticipating them is a common element of many sports (Abernethy, 1991). In contrast, open skills cannot be pre-planned and are typical of a player's gaming experience. In this context we encounter the term reactive agility is part of agility involving movement in response to a changing stimulus. On the one hand, according to Šimonek (2013), it is determined by the quality of control and regulation of CNS and analysers (so-called „information“ ability) and at the same time it is given by the type of muscle fibre (so-called „energetic“ ability). It follows from the above characteristics that the agility capability should be superior to the speed and co-ordination and partly to the strength (dynamic-force) abilities. Agility in team sports includes not only the ability to change direction, but also the ability to anticipate - predict opponent's movement and situation development, „read“ the game and respond to specific game situations (Gamble, 2013). Taking a broader view of the cognitive position in the process-related aspect of movement, we must also consider the role of intelligence and a sort of common centre of control of these processes - the nervous system. The definition of intelligence (one that can be measured by tests) was only a hyperbola of how difficult it is to determine something so complex. For example, Wechsler (1974), the author of the most well-known intelligence test, defines it as the aggregate or overall ability of an individual to act purposefully, think rationally and efficiently with their surroundings. Piaget (1964) publishes that intelligence is the most achievable form of mental adaptation, and the largest form of cognitive structure management. The Guilford (1988) model of intellect structure involves up to 150 factors. The hierarchical model was John Carroll's theory (Beauejan, 2015), which distinguishes intelligence into three basic layers. The first integrates a large number of specific skills (speed, attention, etc.). Blatný & Plhánková (2003) believe that the concept of intelligence can be understood as something that we can measure by intelligence tests. Many other authors have also studied intelligence and cognitive abilities, such as Furnham & Petrides (2003) doing research on students from the best schools. These students reported above-standard results in tests for cognitive abilities, but found no correlation between their school results and their natural intelligence level.

Material & methods

The primary aim of this work was to find out the relationship between intelligence, cognitive abilities and reaction agility. In the relationship analysis, both genders were merged into one research group. The survey included 100 grammar school students aged 17-18 (mean $\pm$ SD: age 17,46 $\pm$ 1,164y). Written statements of informed consent were provided by all participants or their legal representatives, and the testing protocol was approved by the institutional ethics committee. Testing was divided into three main sections, the first focusing on intelligence testing, the second on cognitive abilities, and the third on reaction agility in adolescents. The survey carried out: a) TIP - Intellectual Potential Test (Řičan, 1971); b) Stroop test - level of cognitive functions (Daniel, 1983); c) Y-test-acceleration and response rate with visual signal selection (modified; Figure 1; Lockie et al., 2015). The pupil starts from the starting gate, after passing 3 meters (m), they pass through the starting gate and react to the light signal determining the direction of the run. We first tested normality, and based on the results of testing the normality with the Kolmogorov-Smirnov test (Sig. <0.01), we used a non-parametric form of correlation analysis - Spearman's correlation coefficient. We used Mann Whitney test for finding the differences in the level of both genders. Effect size (ES) – Cohen's "d" was used to assess the extent to which material importance of differences and correlation.

Fig. 1 Modified Y Agility test (Lockie et al, 2015)

Results

We investigated the relationship between reaction agility, intelligence and cognitive abilities in adolescents and we identified differences in the level of reaction agility, intelligence and cognitive abilities in both sexes (Figure 2; Table 1). In our research group, boys (mean value = 2.15 s) achieved significantly better results in reaction agility than girls (mean value = 2.31 s). Table no. 1 shows the result of the Mann-Whitney U test when testing the difference in reaction agility between boys and girls at $U = 778.5$; $Z = -3.021$; $\text{Sig.} < 0.01$. We interpret the differences in the average rankings between groups as statistically significant. Thus, there is a significant difference in reaction agility between boys and girls ($\text{ES } d = 0.27$).

Fig. 2Y test – reactive agility (boys vs girls)

When comparing the mean values of boys and girls in the intelligence test, they used wall standards, where girls scored higher (7.14) on average than boys (7.12). However, the statistically significant difference was not confirmed (Figure 3, Table 1). The assumption of the difference between boys and girls in intelligence was verified by the Mann-Whitney U test with a result of $U = 1160.0$; $Z = -0.353$; $\text{Sig.} = 0.724$. Interpreting differences in average rankings between groups is interpreted as statistically insignificant ($\text{ES } d = 0.56$).

Fig. 3IQ – intelligence test (boys vs girls)

In the cognitive ability test (Stroop test), respondents measured the time, with the mean value in girls being 15.69 seconds and the mean value in boys 15.61 seconds. The result of the Mann-Whitney U test when testing the difference between boys and girls in cognitive abilities reached values of $U = 1101.0$; $Z = -0.760$; $\text{Sig.} = 0.447$ ($\text{ES } d = 0.17$). We can say that the boys in our research group scored on average better than girls, but the statistically significant difference was not confirmed (Figure 4; Table 1).

Fig. 4 Stroop test – cognitive abilities (boys vs girls)

Table 1 Statistic significance of differences (Mann-Whitney U test)

Mann-Whitneyho U test	N	Ø order	U value	Z value	sig.
Reactive agility	Boys	59	43,19	778,50	-3,021
	Girls	41	61,01		
Intelligence	Boys	59	49,29	1160,02	-0,353
	Girls	41	51,34		
Cognitive abilities	Boys	59	48,66	1101,00	-0,760
	Girls	41	53,15		

* - $\text{Sig.} < 0.01$

Table 2 Correlation analysis (Reactive agility – Intelligence – Cognitive abilities)

r	Reactive agility	Intelligence	Cognitive abilities
Reactive agility	x	0,666**	-0,124
Intelligence	0,666**	x	0,021
Cognitive abilities	-0,124	0,021	x

** - Sig.<0,01

The results in Table 2 and Figure 5 show that the correlation analysis did not confirm a statistically significant relationship between performance in reaction agility and cognitive abilities ($\rho = -0.124$). Thus, there is no statistically significant relationship between these indicators in adolescents. This is somewhat surprising as we assumed that both indicators interact (Table 2).

Fig. 5 Scatter plot – Reactive agility vs Cognitive abilities correlation

No statistically significant relationship between the variables ($\rho = -0.021$) was found when determining the relationship between intelligence and cognitive abilities. We note that there is a significant relationship between these indicators in adolescents ($r = 0.021$). Therefore, even in the case of the exclusion of motor functions (reactive agility), we do not observe the dependence of variables (Figure 6). This is probably due to the different localization of the respective brain centres. Thus, the brain operations that carry out these activities (thinking, perception, decision-making) do not interact.

Fig. 6 Scatter plot - Intelligence vs Cognitive abilities correlation

Analysis of the relationship between intelligence and reactive agility (Table 2; Figure 7) showed a statistically significant positive relationship between variables ($\rho = 0.666$) at the selected level of statistical significance

(sig.<0,001). Based on the above, we consider the relationship between variables to be significant. According to our findings, the role of thinking also plays a role in cognitive processes.

Fig. 7 Scatter plot - Reactive agility vs Intelligence correlation

Discussion

Research in the field of reactive agility is found mainly in the field of performance and top sport in football (Baker, 1999), in basketball (Lockie, et al., 2014), in volleyball (Sahin, 2014). Boys dominate in the level of performance in agility during adolescence, which is in line with our expectations. The level of reactive agility is strongly conditioned by perceptive and cognitive abilities (Horička et al, 2018). However, the available evidence confirms that athletes achieve a generally higher level of reactive agility and less conditionality with cognitive abilities. Looking at the intersexual differences in intelligence, it is not possible to clearly determine which gender shows higher values. The reason is a wide range of types of intelligence. Our results showed a slight prevalence of girls over boys, but not statistically significant. This is also confirmed by the results of Rammstedt & Rammsayer (2000), who examined gender differences in up to 7 kinds of intelligence. While in some species boys (mathematical, logical and spatial intelligence) dominated, in others girls (music and interpersonal) did.

Conclusions

The results confirmed differences in the level of reactive agility, intelligence and cognitive abilities in adolescents from both genders. In the case of agility, the dominance of boys could be expected, as it is primarily limited by motor skills. Boys' somatic development is faster in adolescents - boys of this age - than in girls. According to the structure of performance in agility, it is strongly influenced mainly by strength and speed-strength abilities, therefore, a higher level of simple agility in boys is expected. In the case of intelligence level, girls (7.14) reached slightly higher values than boys (7.12). The difference between boys and girls in intelligence was verified by the Mann-Whitney U test with a result of $U = 1160.0$; $Z = -0.353$; Sig. = 0.724. However, these differences were not statistically significant (ES $d = 0.56$). On the other hand, (Stroop test) respondents measured the time, with the mean value in girls being 15.69 seconds and the mean value in boys 15.61 seconds. When assessing differences in cognitive abilities between the two genders, we found higher values in boys than in girls, but not statistically significant (Sig. = 0.447). In the relationship analysis, the gender of the tested persons was not taken into account. Somewhat surprisingly, a significant relationship between reactive agility and intelligence ($r = 0.666$) was confirmed in the group of adolescents studied. For other indicators, the relevant relationship has not been demonstrated. We explain this by the different positions of the centres of movement - motor cortex and centres of performance functions - the frontal lobe in the brain. The wide distribution of correlation coefficients indicates a relatively low conditionality of the monitored indicators (with the exception of intelligence and reactive agility).

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