Original Article

The differences in acceleration, maximal speed and agility between soccer, basketball, volleyball and handball players

JAROMÍR ŠIMONEK ✉, PAVOL HORIČKA, JÁN HIANIK

Department of Physical Education & Sport, Constantine the Philosopher University, Nitra, Slovak

ABSTRACT

Complex reaction speed, acceleration, maximum speed, speed of whole-body change of direction and agility represent the basic components of sport performance mainly in sport games and combat sports. However, contradictory findings have been reported as to the extent of the relationship between the different speed and agility components. This study comprised 117 players (soccer – 56, basketball – 17, volleyball – 20, and handball – 24) playing youth leagues U15-U17 who were assessed for 10-m sprint (acceleration), flying 30-m sprint (maximum speed), triple-jump (special explosiveness) performance, Illinois agility test (speed of whole-body change of direction) and Fitro Agility Check (agility). Low (0.112-0.425 in soccer) correlation coefficients between the factors were found in soccer, while in the other sport games they were medium (0.329-0.623 in basketball; 0.414-0.686 in handball) to high (0.569-0.768 in volleyball). Negative relationship was observed between Triple jump and all other tests performances in all sports games. The findings suggest that specific training procedures for each speed and agility component should be utilized already in junior ages. **Key words:** SPEED TESTS, FITRO AGILITY CHECK, ILLINOIS TEST, SOCCER, BASKETBALL, VOLLEYBALL, HANDBALL, SPORTS TRAINING

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✉ **Corresponding author.** *Constantine the Philosopher University, Tr. A. Hlinku 1, SK – 949 74 Nitra, Slovakia.*
E-mail: jsimonek@ukf.sk
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INTRODUCTION

Sport games performance is characterized by high-speed actions, while sportsmen should take quick decisions and solve the sport-specific tasks occurring during the match. Based on this assumption we can conclude that complex reaction speed, acceleration, maximum speed, speed of whole-body change of direction and agility represent the basic components of sport performance mainly in sport games and combat sports (fencing, boxing, aikido, karate, etc.). Agility is one of the main determinants of performance in soccer, basketball, ice-hockey and handball (Little & Williams, 2005). However, definitions of this quality differ among the sport researchers. The vast majority of tests purported to assess agility are tests for change of direction speed. The basic movement patterns of team sports require the player to perform sudden changes in body direction in combination with rapid movements of limbs and the ability of the player to use these maneuvres successfully will depend on other factors such as visual processing, reaction time, perception and also anticipation. The purpose of most agility tests used at the time is simply to measure the ability to rapidly change body direction and position in the horizontal plane. Illinois agility test has long been standardly used for testing agility. The same situation exists among the coaches. They are not acquainted with adequate motor tests used for the determination of agility performance in the modern understanding. Illinois test is still very frequently used for the assessment of agility and speed in sport games (Young, McDowell, & Scarlet, 2001; Gambetta, 1996; Young, Hawken, & McDonald, 1996; Buttifant, Graham, & Cross, 1995). This test has got several versions in order to suit the purposes of individual sport games. Simply said, they think that the performance in this test will show them the quality of speed abilities of sportsmen. In a real sport match in sport games, however, players do not have to run from a line to a line, they neither have to run around some cones. When we take a closer look into the test and analyse the sportsman´s movement, we can see that speed and agility in team sports represent complex psychomotor skills (Verchoshansky, 1996). They involve moving the body as rapidly as possible, but agility has the added dimension of changing direction. Speed is classically defined as the shortest time required for an object to move along a fixed distance, which is the same as velocity, but without specifying the direction (Harman & Garhammer, 2008). In practical terms, it refers to the ability to move the body as quickly as possible over a set distance. However, in reality, the issue is slightly more complex because speed is not constant over the entire distance a can therefore be divided into several phases: acceleration, maintenance of maximum speed and deceleration (Plisk, 2008). Agility is most often defined as the ability to change direction rapidly (Altug, Altug & Altug, 1987). This can take many forms, from simple footwork actions to moving the entire body in the opposite direction while running at a high speed. Thus, agility has a speed component, but it is not the most important component of this trait. The basic definition of agility is too simplistic, because it is now thought to be much more complex invo lving not only speed, but also balance, coordination, and the ability to react to a change of the environment (Plisk, 2008). Měkota (2000) considers agility to be physical capability, which by its essence belongs among „mixed“ physical capabilities. It is determined by the quality of regulation (CNS) and analysers, as well as the type of muscle fibre. Therefore, agility should be superior to speed, quickness and coordination abilities. In the past, this term used to be understood as the ability to change direction, or to start and stop the movement quickly (Gambetta, 1996; Parsons & Jones, 1998). Similar morphological and biochemical factors of maximal speed, acceleration speed and agility lead some authors to the assumption that the given abilities are related and interdependent. Despite that, Buttifant, Graham, and Cross (1999) did not succeed in finding significant correlation between straight-forward sprinting and agility in two different groups of Australian soccer players. Correlation between agility, acceleration speed and maximal speed was neither found in the group of 106 Australian soccer players who were assessed for 10-m sprint (acceleration), flying 20-m sprint (maximum speed), and zig-zag agility performance (Little & Williams, 2005). Although performances in the three tests were all significantly correlated ($p < 0.0005$), coefficients of determination ($r(2)$) between the tests were just 39, 12, and 21% for acceleration and maximum speed, acceleration and agility, and maximum speed and agility, respectively. Based on the low coefficients of determination, it was concluded that acceleration, maximum speed, and agility are probably specific qualities and relatively unrelated to one another. The findings suggest that specific testing and training procedures for each speed component should be utilized when working with elite players. Young, Benton, Duthie, & Pryor (2001) based on their research proved that if agility and speed abilities are connected with the performance of sport specific skill, inter-correlation decreases even more. This can be caused also by the fact that training methods of their development are specific for each of the types of speed abilities, thus minimum transfer of qualities between them occurs (Young, McDowel, & Scarlett, 2001).

As far as speed components are considered, it has traditionally been thought that strength and power development would enhance change of direction (COD) performance. According to Brughelli, Cronin, Levin & Chaouachi (2008) the most common approach to quantifying these relationships, and to discovering determinants (physiological and mechanical) of COD performance, is with correlation analysis. There have not been any strength or power variables that significantly correlated with COD performance on a consistent basis and the magnitude of the correlations were, for the most part, small to moderate. The training studies in the literature that have utilized traditional strength and power training programmes, which involved exercises being performed bilaterally in the vertical direction (e.g. Olympic-style lifts, squats, deadlifts, plyometrics, vertical jumping), have mostly failed to elicit improvements in COD performance. Conversely, the training protocols reporting improvements in COD performance have utilized exercises that more closely mimic the demands of a COD, which include horizontal jump training (unilateral and bilateral), lateral jump training (unilateral and bilateral), loaded vertical jump training, sport-specific COD training and general COD training.

Sheppard & Young (2006) also claim that speed and agility represent independent physical abilities and therefore their development requires high degree of neuro-muscular specificity. Perceptual components, which form their fundament and include also anticipation and decision-making processes, play also an important role in their development (Young, James, & Montgomery, 2002). However, they are specific for various kinds of sports and players´ posts. As to Šimonek (2013) agility comprises several universal components. Horička, Hianik & Šimonek (2014) did not find any statistically significant differences between the players of various sport games (basketball, volleyball and soccer) as to agility performance. All the games require high quality of perceptual and decision making processes (Gamble, 2013).

Since based on the literature analysis contradictory findings have been reported as to the extent of relationship between the different speed components and agility we came to the conclusion that it is inevitable to go deeper in the research of various manifestations of speed and agility especially in sport games.

MATERIALS AND METHODS

Participants

This study comprises 117 male junior (U15 and U17; M_{age}=14.95 y.; SD=1.93 y.) players out of which 56 soccer players (U15 n=31; U17 n=25), basketball players (U15 n=9; U17 n=8), volleyball players (U15 n=8; U17 n=12) and handball players (U15 n=12; U17 n=12). Different number of players in each category was caused by objective facts and state of health of players, who play for the junior teams in the region of Nitra, Slovakia. Average sport age of players was 3-6 years.

Procedures

Assessment of speed abilities and agility was carried out in the months of September through November 2014. The following testing procedures were implemented:

1. 10 m sprint (semi-high start position);
2. Flying 30 m sprint;
3. Triple jump (changing legs);
4. Illinois agility test (Getchell, 1979);
5. Fitro Agility Check (hereinafter referred to as FAC) (Zemková & Hamar, 2009).

The level of speed abilities was tested using standardized test protocols. Agility performance was measured using special testing facility called Fitro Agility Check (FAC) by the firm Fitronic (Hamar, 1997), which consisted of 4 square mats (35 x 35 cm) 3 m apart, placed on the floor and interconnected with the computer. Tested player stands in the middle of the tested area and his task is to quickly react to the visual stimulus (red circle on white background) appearing alternately in one of the corners of the display by step ping on the correct mat (front- right, front-left, rear-right, rear-left). The test protocol included 16 (4 to each direction) randomly generated stimuli appearing in the time interval of 2000 ms. Reaction time was registered using the software by Zemková & Hamar (2009). The value of arithmetic mean of 16 recorded times (ms) was included into the record protocol. Extreme values caused by injury or incorrect technique were expelled from the statistic processing.

Analysis

The obtained data were statistically evaluated using the following statistical methods:

The primary method of our research was quantitative absolute research. For the assessment of the rate of relationship between individual examined motor abilities pair correlation analysis was used. Softwares Statistixl and MS Excel 2010 were used for the calculation of coefficients. The character of dependences was interpreted according to Cohen (1988).

RESULTS AND DISCUSSION

When interpreting the research results we draw from the assumption that the leve l of examined speed abilities and agility in players of four selected sport games will not significantly differ with regard to the similar character of movement of players (Horička, Hianik & Šimonek, 2014). From the point of view of comparison of players in the examined sport games we found the following facts.

In the test assessing the level of simple reaction and acceleration speed (10m sprint; Figure 1) we found the highest level in cadet volleyball players ($\bar{x} = 1.85s$), handball players ($\bar{x} = 1.89s$), basketball players ($\bar{x} = 1.9s$) and football players ($\bar{x} = 1.92s$). A relative steadiness in performances, similarly as in FAC test, was observed in both age categories of handball players. Rather surprising seems to be the reverse ranking of players in the category of pupils, where best performances recorded handballers ($\bar{x} = 1.94$) and the worst basketballers ($\bar{x} = 2.285s$).

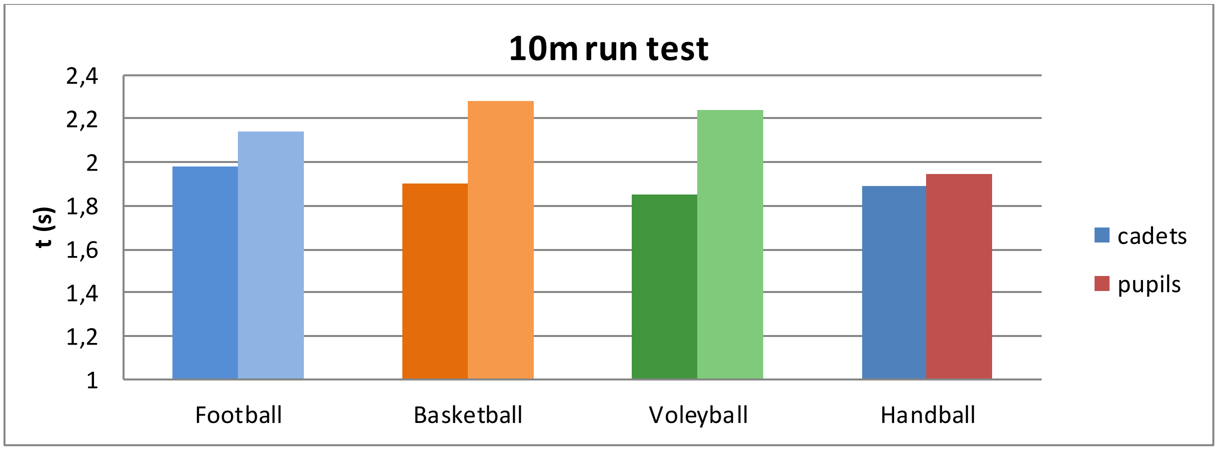

Figure 1. Comparison of U15 (pupils) and U17 (cadets) performances in 10 m sprint among sports

In the test of maximum running speed Flying 30 m sprint (Figure 2) football players clearly dominate ($\bar{x} = 3.73s$), which was probably caused by the character of play in a match, where players move within a wider area, and also by a different structure of training load. Handball players ranked second ($\bar{x} = 3.88s$), volleyball players third ($\bar{x} = 3.95s$), and basketball players ranked last ($\bar{x} = 4.02s$). The surprising order (2nd and 3rd places) of players can be a consequence of a worse quality of maximum running speed of cadets in basketball, since the worst results as expected were recorded by volleyball players ($\bar{x} = 4.25s$).

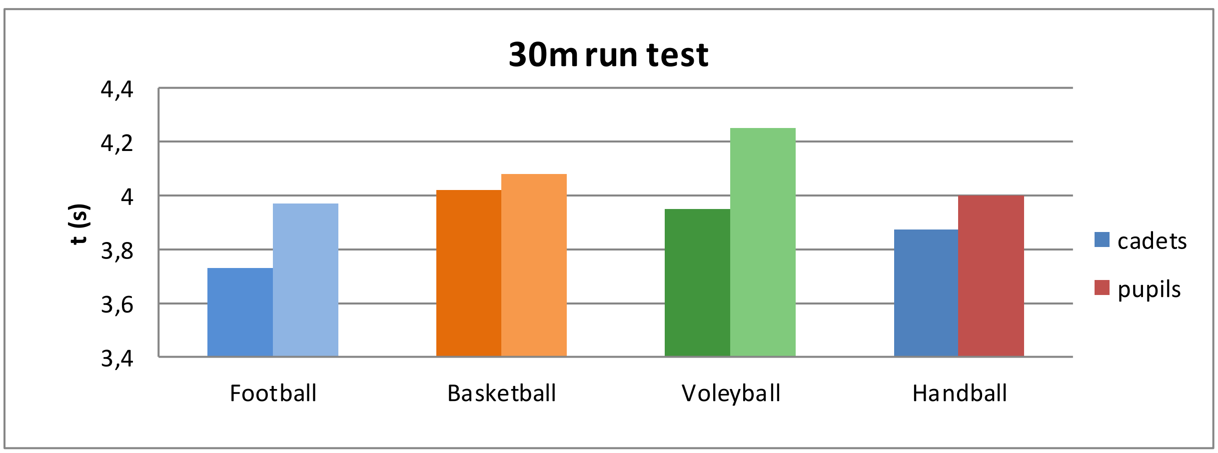

Figure 2. Comparison of U15 (pupils) and U17 (cadets) performances in Flying 30 m among sports

In the test assessing jumping explosiveness (Triple jump; Figure 3) the highest level of explosiveness was recorded in cadet volleyball players ($\bar{x} = 10.13m$), basketball players ($\bar{x} = 9.97m$), while the lowest in football players ($\bar{x} = 9.31m$). In pupils´ category dominate handball players ($\bar{x} = 9.01m$), which can be caused by lower rate of adaptation to loading in the early sport age.

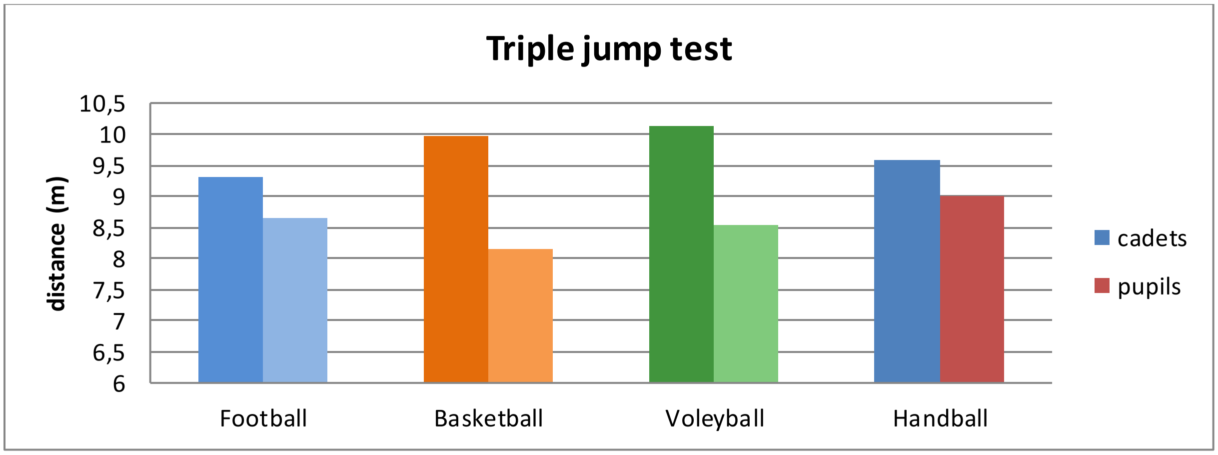

Figure 3. Comparison of U15 (pupils) and U17 (cadets) performances in Triple jump among sports

In the test assessing speed of changing the direction as a reaction to a standard stimulus (open skill) - Illinois test – the best results were observed in cadets in volleyball ($\bar{x} = 15.76$), basketball ($\bar{x} = 15.82s$) football ($\bar{x} = 16.35s$) and handball ($\bar{x} = 15.355s$). In the pupils´ category dominated volleyball players ($\bar{x} = 16.23s$) followed by football, basketball and handball players (Figure 4).

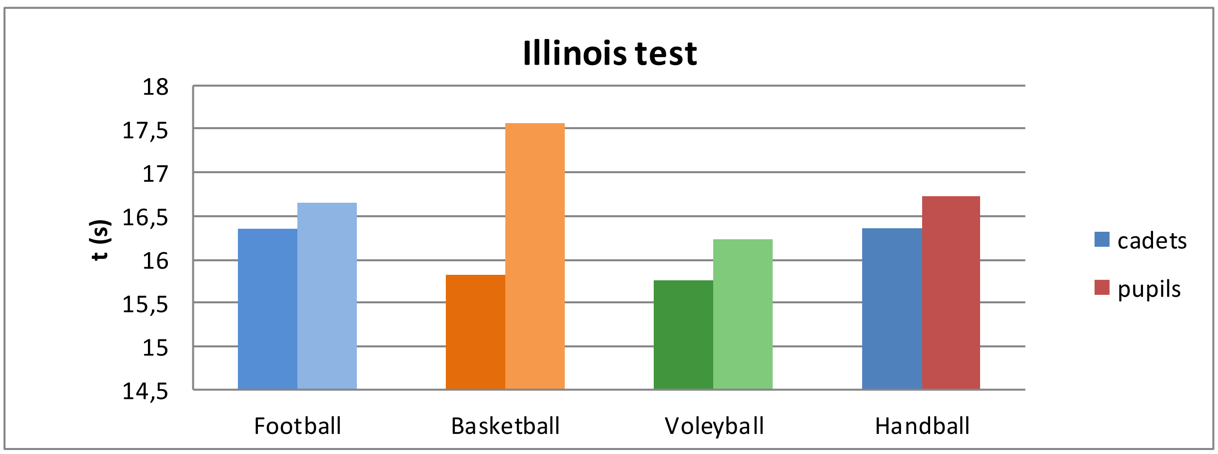

Figure 4. Comparison of U15 (pupils) and U17 (cadets) performances in Illinois test among sports

In the diagnostics of agility and perception in the test requiring quick decision-making and choosing the adequate motor reaction (FAC, Figure 5) we observed a smaller variability in the performances of players. Differences in players´ performances were negligible, except for the ones between the age categories. The best performances were recorded in football players ($\bar{x} = 1284.6ms$), followed by volleyball players ($\bar{x} = 1294.7ms$), basketball players ($\bar{x} = 1344.33ms$) and handball players ($\bar{x} = 1420.9ms$). In this test a smaller variability between both age categories was observed mainly in handball. This is probably because of the fact that coordination (reaction speed and perception) is not limited by the level of fitness factors (speed, strength, special endurance), but by the quality of analysers and central nervous system and its role in the movement control from the point of view of the age of sportsmen.

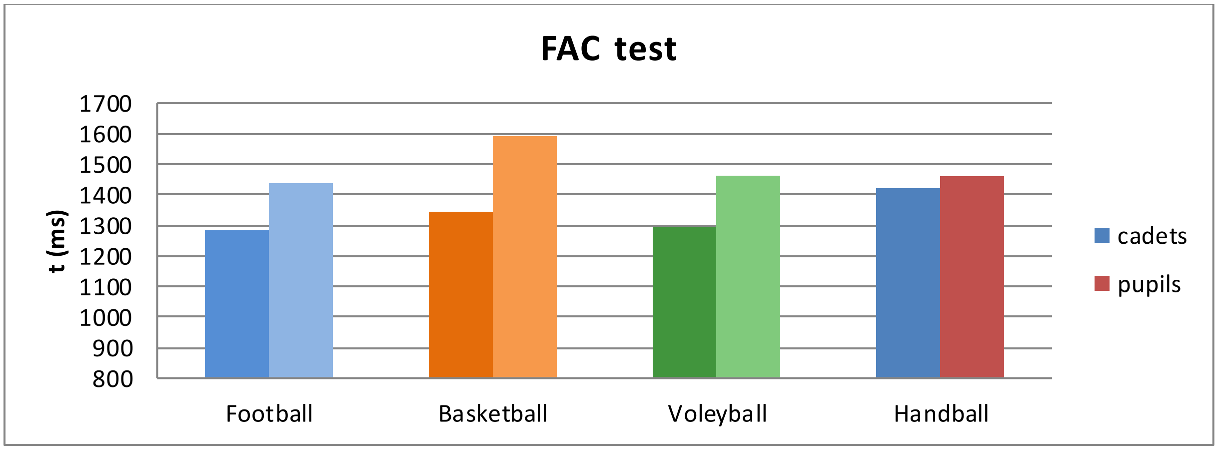

Figure 5. Comparison of U15 (pupils) and U17 (cadets) performances in FAC test among sports

When assessing the rate of dependence of selected indicators we can observe low values of correlation coefficients (r) in football players (Table 1). Negative polarity in the test Triple jump (in all cases) can be interpreted as negative to low relationship of explosiveness with other speed and coordination abilities.

Table 1. Descriptive statistics and correlation coefficients - Football

Pearson Correlation Results for: Football									
Descriptive Statistics					**Correlation Matrix (R)**				
Variable	**Mean**	**Std Dev.**	**Std Err**	**N**	**Illinois**	**FAC**	**10m**	**30m**	**Triple jump**
Illinois	16,432	0,591	0,078	56	1,000	0,425	0,288	0,244	-0,626
FAC	1390,546	116,747	15,464	56	0,425	1,000	0,112	0,340	-0,398
10m	2,058	0,365	0,048	56	0,288	0,112	1,000	-0,536	-0,292
30m	3,815	0,312	0,041	56	0,244	0,340	-0,536	1,000	-0,281
Triple jump	9,025	0,717	0,095	56	-0,626	-0,398	-0,292	-0,281	1,000

In case of basketball players a similar character of relationship can be seen, however, with higher values of correlation coefficients (Table 2; r = 0,586 – 0,631), mainly in case of the relationship between the result in Illinois test and the ones in the remaining tests. Even higher values of r can be observed in the test Triple jump, mainly in the relationship with the speed of changing the direction of movement (Illinois test). Similar results were found in case of the relationship with maximum running speed (10 m vs 30 m tests).

Table 2. Descriptive statistics and correlation coefficients - Basketball

Pearson Correlation Results for: Basketball									
Descriptive Statistics					**Correlation Matrix (R)**				
Variable	**Mean**	**Std Dev.**	**Std**	**N**	**Illinois**	**FAC**	**10m**	**30m**	**Triple jump**
Illinois	16,655	1,441	0,350	17	1,000	0,631	0,586	0,623	-0,691
FAC	1463,59	218,90	53,09	17	0,631	1,000	0,351	0,019	-0,510
10m	1,992	0,154	0,037	17	0,586	0,351	1,000	0,329	-0,412
30m	4,036	0,207	0,050	17	0,623	0,019	0,329	1,000	-0,518
Triple jump	9,383	0,925	0,224	17	-0,691	-0,510	-0,412	0,518	1,000

Similar tendencies can be found also in volleyball (Table 3). High values of correlation coefficients (r) - exceeding the value of 0.5 – suggest that there is high relationship between the observed variables – speed of changing the direction (Illinois test) and other speed abilities, with an exception of Triple jump test. This relationship can be seen mainly in case of 10 m and 30 m tests (r = 0.768), and FAC and 10 m test, where the value r reaches also high level (r = 0.708). Similarly to football and basketball, correlation coefficients in the test Triple jump are negative (r = -0.635 – 0.829).

Table 3. Descriptive statistics and correlation coefficients - Volleyball

Pearson Correlation Results for: Voleyball									
Descriptiv Statistics					**Correlation Matrix (R)**				
Variable	**Mean**	**Std Dev.**	**Std Err**	**N**	**Illinois**	**FAC**	**10m**	**30m**	**Triple jump**
Illinois	15,950	0,615	0,138	20	1,000	0,569	0,592	0,626	-0,635
FAC	1361,67	121,39	27,144	20	0,569	1,000	0,708	0,609	-0,641
10m	2,008	0,217	0,049	20	0,592	0,708	1,000	0,768	-0,790
30m	4,068	0,260	0,058	20	0,626	0,609	0,768	1,000	-0,829
Triple	9,493	1,180	0,264	20	-0,635	-0,641	-0,790	0,829	1,000

When assessing the relationship of indicators of performance in handball we observe a relatively high relationship in maximum running speed (30 m sprint) and agility, or acceleration speed (10 m sprint) with the value r = 0.686. In case of the remaining abilities this dependence is just slight (Illinois vs. 10 m sprint; r = 0.597) or low with the value of r lower than 0.5.

Similarly as in the previous sport games, explosiveness showed negative relationship with speed and agility performances. All values of correlation coefficients showed negative polarity (Table 4).

Table 4. Descriptive statistics and correlation coefficients - Handball

Pearson Correlation Results for: Handball									
Descriptive Statistics					**Correlation Matrix (R)**				
Variable	**Mean**	**Std Dev.**	**Std Err**	**N**	**Illinois**	**FAC**	**10m**	**30m**	**Triple jump**
Illinois	16,632	1,021	0,208	24	1,000	0,464	0,597	0,686	-0,581
FAC	1447,00	117,44	23,973	24	0,464	1,000	0,431	0,414	-0,445
10m	1,919	0,090	0,018	24	0,597	0,431	1,000	0,686	-0,574
30m	3,952	0,183	0,037	24	0,686	0,414	0,686	1,000	-0,569
trojskok	9,335	0,625	0,128	24	-0,581	-0,445	-0,574	-0,569	1,000

CONCLUSIONS

By comparing the levels of individual speed factors (reaction, acceleration, maximal running speed, explosiveness and agility) in the observed groups of cadets we can see that volleyball players dominated in four out of the five indicators (Illinois, FAC, 10 m sprint and Triple jump). In the category of pupils there is no such dominance and the differences between the sport games are wiped away. This fact can result from the shorter period of adaptation to the training and competition load, and probably also the result of fading away of sensitive periods for the development of speed factors in younger age category. The dominance of volleyball players in speed-strength component is clear only in the cadet category.

We also came to an interesting conclusion that there were very slight differences in the level of agility among the players in the four different sport games. This was probably due to the demands of all sport games on perception and quality of reaction in open skills performances. The smallest variability in both age categories was found in handball players. The worst results were observed in cadet handball players, but in pupils the opposite was the true.

The primary aim of our study was to assess the rate of dependence among individual speed abilities (Illinois test, 10 m sprint, 30 m sprint), explosiveness (Triple jump), and agility (Fitro Agility Check - FAC). We can state low values of correlations in football almost in all the relationships. On the contrary, in basketball high rate of dependence was found, mainly in Illinois test and the other tests of abilities. Negative relationship was observed in all examined sport games in case of explosiveness and the remaining speed abilities. This relationship points out to the negative impact of this ability onto reaction and realization speed as well as agility.

In accordance with the findings of Horička et al (2014) we observed very low relationship between the speed of changing the direction of movement tested by Illinois test and agility (complex multi-choice reaction) tested by Fitro Agility Check with the exception of volleyball players. This suggests that ability does not appear to be strongly linked with straight-speed components. Speed and agility are distinct physical qualities, and speed training does not appear to enhance change of direction speed. Therefore, training for change of direction speed and agility must involve highly specific training that recognizes specific demands of the sport.

The findings in our study suggest that specific training procedures for each speed and agility component should be utilized already in junior ages.

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