Agility in Sport

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PREFACE

The purpose of this book is to introduce a new perspective of agility theory, a practice of training and testing. Recently, there has been a great deal of serious discussion concerning the methods of open-loop skills improvement in team games and combat sports. Experts have discussed methods of developing reactive and running agility. However, there is a lack of experimental work to prove these theories in sports practice. This book offers experimental research results as well as theoretical knowledge of both types of agility. Agility training methods and exercises are presented in the penultimate chapter of the book. This material can be used in training by coaches and trainers in sports games and combat sports. The lack of research samples forms the limitation of the book.

In one sentence, describe your book:
The book presents a comprehensive view of agility performance in sport.

The comprehensiveness of elaboration on the topic is unique. It is based on the personal testing experience of the authors. Personal trainers, sports coaches, P.E. teachers, professional athletes, sports students at universities, recreational athletes, will be the potential audience for this book.

INTRODUCTION

Recently, a top sport has been characterized by high sports performance, perfect technique, high levels of motor skills and abilities, and as one that places high demands on the motor, psychological and physiological aspects of an athlete´s personality. Thus, the question of increasing effectiveness of sports preparation has come to the forefront. The core content of sports preparation has gradually passed from quantity to quality, from general to specific means. Trainers and coaches have been searching for more effective means of developing skills and abilities, focusing also on the more effective exploitation of training time. The quality of sports training rests on the exploitation of “sensitive periods” for the development of motor prerequisites crucial for the given sport.

Sports games require a high level of specific movements, represented by perfect mastering of the technique of individual skills. The ability to move quickly, and to change direction and speed of movement while accelerating and decelerating, belong among the core ones. However, the athlete would not be successful if they did not use their cognitive skills to react to the constantly changing game situations in a match. Athletes with high levels of anticipation and mental processes, as well as high speeds of decision-making, show improved effectiveness in their motor performance.

Similar to sports games, martial arts are sports where athletes´ degree of successfulness depends, besides perfect mastering of the technique of skills, on their ability to regulate their mental processes. Reactive agility also belongs among the fundamental qualities. Experts in the field of conditioning have elaborated a new theory of training of agility in both its forms: running and reactive ones.

This book presents a comprehensive view of agility performance in sport. It has been designed for personal trainers and coaches in sports games and martial arts, for P.E. teachers in schools, professional athletes, sports students at universities, recreational athletes, researchers, as well as for the public interested.

The aim of this work is to explain, to trainers and coaches, the difference in reactive and running agility and offer them methods of training agility separately, with a specific focus on the core skills in the given sport.

The task of this monograph is to submit different training means**,** focusing on the development of agility for the stage of initial sports preparation and initial specialization as well as the specialized sports preparation stage. The application of the above-mentioned means should result in the improved motor display of a sportsperson, faster acquisition of motor skills, as well as a higher percentage of effectivity in a game.

CHAPTER ONE

DEFINITION OF TERMS

In this chapter, the authors attempted at defining basic terms used in the area of sports preparation. Some parts of this chapter were adapted from the monograph of one of the authors (Šimonek, 2014) which was published in De Gruyter Publishing.

Sports preparation itself represents a complex system of phenomena, connections, and behaviour of its components. If the coach wants to reach the goal of sports preparation – to nurture a top athlete able to reach an optimum performance in any conditions – he/she has to try, based on thorough knowledge of the individual, of specific age, gender, and developmental peculiarities, to create a comprehensive system of long-term sport preparation. This presupposes application of adequate and effective training means, methods and forms of work, optimum training loads and suitable frequency, and follow-up in training cycles (Šimonek, 2014). To solve this crucial task for the trainer (coach), they have to be familiar with the structure of performance in the given sport.

Nowadays, rarely any sports expert doubts the contribution of factors like speed, quickness, explosiveness, the speed of frequency, coordination abilities to the sports performance in speed-strength events and sports games.

In volleyball, a very high speed of reaction and reactive agility are required to be able to control balls on serve reception, especially in field defence. Many authors consider motor abilities, agility and explosive strength, along with pronounced longitudinal skeleton dimensionality, as the major characteristics for successful volleyball performance (Morales, 2002; Stamm, Veldre, Stamm, Thomson, Kaarma, Loko, & Koskel, 2003). Sports training focusing on the development of speed-strength and coordination abilities (mainly dynamic balance, reaction speed, spatial orientation) and reactive agility, contributes to an increase in sports performance and reduces the risk of injury. Unfortunately, many of the known “classical” training programmes do not fulfil these aims. In reality, many athletes who have adhered to these old-fashioned training programmes do not reach required accruals and often suffer from recurrent injuries. Reasons for the above-mentioned conditions can be easily explained. All movement can be broken down into three planes of motion or directions – forwards and backward (the Sagittal Plane), side to side (the Frontal Plane), and rotational movement (the Transverse Plane) - and three muscle actions – acceleration (concentric), stabilization (isometric), and deceleration (eccentric). Most sports require the ability to move explosively in all three directions or to accelerate quickly, decelerate, stabilize functionally and accelerate explosively again. Yet, older and more ineffective forms of training have traditionally emphasized just one plane of motion (the sagittal plane – for example, sprints, squats, lunges leg presses and leg curls), and one muscle action – primarily acceleration. But functional movement and competitive sports are just not like this in practice, which is why close to 80% of all sports injuries occur without any contact with opponents, and usually when an athlete decelerates and rotates (such as during a change in direction). Athletes must train in all three planes of motion and with all muscle actions (acceleration, deceleration, stabilization) to create a much safer and more effective program. In addition, workouts should be both age-specific and sport specific. This is very important. A nine-year-old soccer player should not be using the same program as a fourteen-year-old basketball player or a nineteen-year-old hockey player. Trainers should construct a needs analysis of the sport- what are the dominant lanes of motion and muscle actions used by the sport and position of the athlete? We need to know the energy/endurance demands, the rest ratios, level of intensity demanded in each phase of the game and for each position. A program should be built around these components. Finally, the use of effective goal setting and training logs and charts to measure and monitor progress and improvements is an additional, often ignored, component that is very important to overall motivation levels, and thus to the overall success of any explosive speed, agility, and quickness program.

Table 1.1 shows the position of indicators of functional preparedness of an athlete according to its importance in the given sport. In sports games and martial arts, we can find analysers in the first level of importance, while in the second one these are functional systems of the organism. It is inevitable that we focus our attention on these factors in the sports preparation of children and youth.

Table 1.1 Distribution of indicators of functional preparedness of an athlete according to their importance (Nabatnikovová, 1982).

Level of importance	***Groups of sports***				
	Explosive	***Cyclic***	***Demanding a high degree of coordination***	***Martial arts***	***Sports games***
I	1,2	1,5,7,8,9	1,2,3,6	1,2,3,6	1,2,3,4
II	6	2,3,6,10	4,5,7,8,9	5,7,8,9	5,6,7,8,9
III	5	4	10	4,10	10
IV	3,4				

Explanations: 1 – kinaesthetic analyser, 2 – vestibular analyser, 3 – visual analyser, 4 – acoustic analyser, 5 – endocrine system, 6 – peripheral muscle-nerves system, 7 – cardio-vascular system, 8 – respiratory system, 9 – the system of metabolism, 10 – thermal regulation system.

Let us define the crucial terms connected with effective sports preparation: *Sport training* is a process of complex biological, psychological, and social adaptations in which an athlete is systematically loaded by a set of specific stimuli, in order to improve reactions and form; develop motor abilities and personal qualities; acquire knowledge, motor skills, tactical acting, and behaviour; and to improve sport mastery (Šimonek, 2014).

Agility is the key complex motor ability in team games. Sports with the highest level of this ability include soccer (8.25 points out of 10 maximum possible points), basketball (8.13), tennis (7.75), ice hockey (7.63), badminton (7.38), squash (7.25), volleyball (7.00), and ice-skating (6.88) (http://sports.espn.go.com/espn/). This term comprises the ability to stop, rapidly change direction, and accelerate in response to an external cue. In many sports games and combat sports (Bloomfield, Polman, O´Donoghue, & McNaughton, 2007; Gabbett, Kelly, & Sheppard, 2008a; Little & Williams, 2005), top athletes should have acquired a high level of **agility**.

Some literature uses the term *quickness* synonymously with *agility* or *change-of-direction speed* (Moreno, 1995; Sheppard & Young, 2006a). However, Sheppard and Young (2006a) suggested that the definition of *quickness* has its limitations as it does not consider deceleration or a change of direction and implies that quickness, in and of itself, contributes to agility. The literature indicates that agility must consider not only speed but also the ability to decelerate, change direction, and reaccelerate in response to stimuli. Agility is thus a complex set of independent skills that converge for the athlete to respond to an external stimulus with rapid deceleration, change of direction, and reacceleration (Sheppard and Young, 2006a; Young, James, & Montgomery, 2002). These experts suggest that agility is affected by the athlete´s perceptual and decision-making ability and the ability to change the direction quickly. In addition to the sensory and cognitive abilities involved in reacting to a stimulus and initiating the movement response, the constraints of agility may also demand elements of anticipation and decision-making. For example, when intercepting a ball, skilled players often employ a predictive movement strategy which is initiated in advance based on the anticipated trajectory of the ball (Gillet, Leroy, Thouvarecq, Megrot, & Stein, 2010). Recently, Young, James, and Montgomery (2002) outlined a comprehensive definition of agility in the context of running sports, such as soccer. The researchers addressed the multi-faceted influences involved in agility performance. In particular, the authors outlined that there are two main components of agility – change of direction speed, and perceptual and decision-making factors. Within these two main components, sub-components exist (Fig. 1-1).

Sheppard and Young (2006a) redefined agility as a rapid whole-body movement, with the change of velocity or direction, in response to a stimulus. This definition implies three information-processing stages: stimulus perception, response selection, and movement execution. The first two components of agility performance can be estimated by measuring simple and multi-choice reaction time. Reaction time is an inevitable component of open-loop skills required in many sports games (for example - basketball, handball, soccer). Decision time strongly influences total reactive agility time. According to Young and Willey (2010), decision time has the highest correlation with the total time. Thus, decision time can be considered as the most influential, of the test components, for explaining the variability in total time. Most skilled elite players differ from less skilled players in this component (Farrow, Young, & Bruce, 2005). They show fast reactions thanks to the fast decision-making processes, which are based on anticipation and experience. The third component of agility performance is movement execution. This depends on the ability of a player to initiate the movement as quickly as possible by taking the first stride. We can assume a stronger correlation between maximal step velocity and agility time, over a shorter than a longer distance (Little & Williams, 2005).

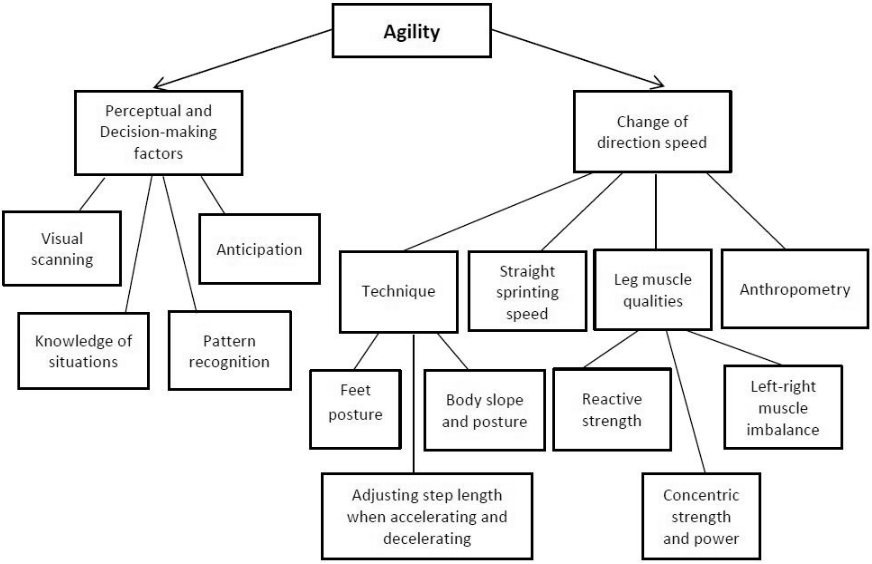
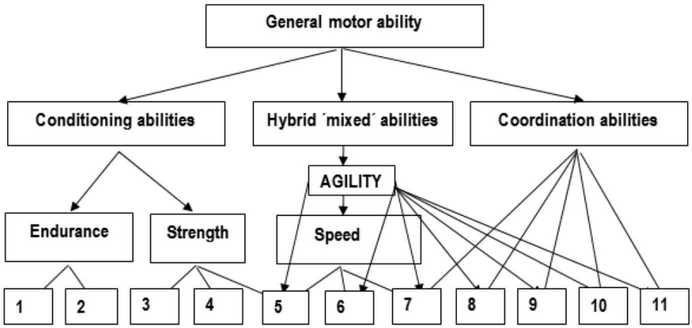


Fig. 1-1 Universal components of agility (Sheppard & Young, 2006a)

Zemková (2016b), in her recent study, found out that acceleration and deceleration phases impact more on agility performance over short than longer distances, but the reactive agility test only provides information on agility time, which includes both reaction time and movement time. The traveling distance thus should be adjusted to the real sport-specific situations.

Šimonek and Kazár (2016) presented a unique structure of general motor ability, which, in line with Verkhoshansky (1996) and Měkota (2000), considers agility to be a hybrid and complex motor ability compound of different abilities, such as explosiveness, frequency of movements, action speed, reaction speed, dynamic balance, rhythm, spatial orientation, amongst others (Fig. 1-2).



Legend: 1 = aerobic endurance; 2 = anaerobic endurance; 3 = strength endurance; 4 = maximum force; 5 = explosive force; 6 = action rate; 7 = reaction rate; 8 = balance ability; 9 = rhythmic ability; 10 = spatial orientation ability; 11 = kinesthetic- differentiation ability.

Fig. 1-2 Position of agility within the hierarchical structure of motor abilities (Šimonek & Kazár, 2016).

Though agility requires the use of cognitive components, it is also composed of other qualities – namely ‘physical’ and ‘technical’. Together, these qualities (cognitive, physical, and technical) form agility (Fig. 1-3). This combination of independent qualities, plus the unplanned nature of agility, means agility has been referred to as a complex and open motor skill in its own right (Jeffreys, 2006).

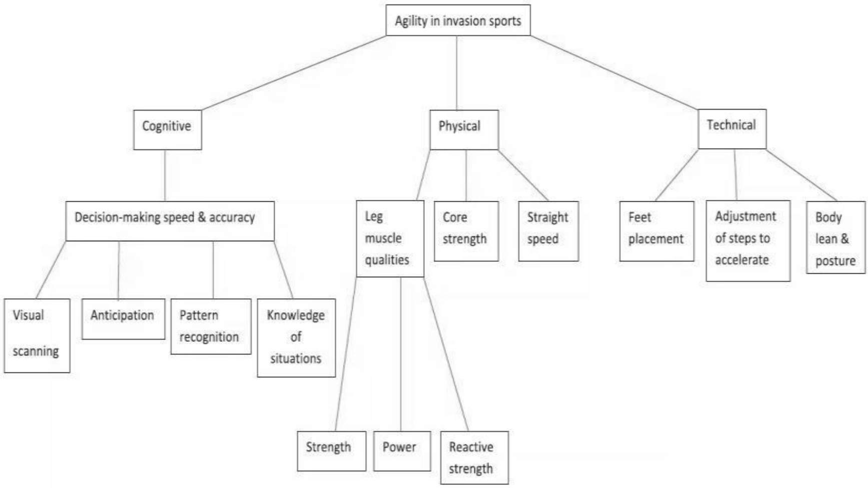


Fig. 1-3 The components of agility (Young, Dawson, & Henry, 2015)

Coordination can be defined as "cooperation of the central nervous system and skeletal muscles within some aimed movement procedure" (Holmann & Hettinger, 1990). Quality of coordination depends principally on the processes of movement control and the connected nerve-muscular processes, as well as on the level of analysers.

Movement coordination is defined as "temporal, spatial and power control of individual movements or complex motor expressions, which are executed with regard to tasks and goals handed over through senses" (Mechling, 1983).

Coordination abilities are defined by Hirtz (1985) as "complex, relatively independent prerequisites of performance regulation of movements, which are created and developed in motor activities based on dominant, inherited but influenceable neuro-physiological functional mechanisms and therefore, they can be improved by means of a methodical training". Kirchem (1992) states that the terms "skill" and "agility", that were previously used, were not able to explain the complexity of coordination abilities and to describe their structure.

Reaction speed is the ability to react quickly by an adequate (standard or non-standard) movement activity on a certain stimulus (acoustic, optic, tactile, kinaesthetic) or actual change of situation (Hirtz, 1985). Impulse can be also a moving object (ball, puck, teammate, an opponent). We differentiate between a simple and complex motor reaction. In sports games and combat sports, complex motor reactions (a reaction with an option) are the most common requirement; this requires fast selection from various options of such motor reaction, depending on which is most appropriate and effective for the given situation, and which is most likely to lead to success. Gamble (2013) states that perception-action coupling and decision-making are critical elements in terms of developing the ability to express reaction speed and agility capabilities under match conditions.

Space–orientation ability is an ability to learn fast and adequately change the position and movements of the body in space and in relation to the external environment (court lines, teammates, opponent, ball, goal) (Hirtz, 1985). This enables the player to have an accurate orientation in any game situation, and coordinate movements in compliance with the real movement task. This depends, to a great degree, on the quality of vestibular apparatus.

Rhythmic ability is an ability to grasp and simulate temporal and dynamic segmentation of the course of movement (Hirtz, 1985). We speak mostly about accommodation of the movement to the given (external) rhythm or finding an optimum and effective internal rhythm, allowing for higher effectiveness of the motor activity. Related to this is also the ability to adapt to the motor rhythm of other athletes, the team, and the change in the rhythm of playing, and to enforce one´s own rhythm to the opponent.

Balance ability is the ability of an individual to maintain or restore the balance of the body in situations where a fast or unexpected change in body position has occurred (Hirtz, 1985). Balance involves a host of sensorimotor capacities, comprising input from visual, vestibular and somatosensory systems (Bressel, Yonker, Kras, & Heath, 2007). It plays an important role, particularly in ice hockey. It depends on the size of the weight-bearing surface, the body's centre of gravity, and the state of the vestibular system and the CNS. Information from the vestibular systems is extremely important in terms of maintaining balance. We differentiate static and dynamic balance - from the point of view of sports games, a high level of dynamic balance is required.

Elaboration of the program of sports preparation is a difficult and complex task, requiring thorough knowledge of the reality of this kind of sport, as well as honest preparation for its realization. Since motor activity in sports games and combat sports is of a non-standard character, it is very difficult to create a serious universal program of sports preparation. Long-term sports preparation, through the application of an optimum focus and content of preparation, should ensure a gradual development of all those factors of the structure of sports performance thus conditioning sports performance to a crucial degree (Šimonek, 2014).

From this point of view, it is important to know all the factors that form the structure of sports performance in the given sport. This requires applying optimum focus and content of preparation, the procedure of reaching this target status, as well as information on desired changes of individual factors of performance in compliance with age-related developmental changes. An important prerequisite of the effectiveness of sports preparation is an adequate application of training loads, optimum in volume, intensity, coordination complexity, and psychological demands, as well as a gradual and sufficiently progressive increase in individual stages of the long-term sports preparation. A key part of sports training in sports games is the fulfilment of various tasks, these are called components of sports preparation. Only acquisition of all the components, which create a complex mosaic of the process that is called sports training, can lead to an optimum growth of performance level (Šimonek, 2014).

Individual components are represented in sports training in various proportiona depending on the period in which the athlete is situated. Besides other components of sports preparation - such as technical, tactical, theoretical, psychological preparation, and medical observation - conditioning plays the most important role as it is the decisive determinant for all sports activities. The importance of conditioning is manifested in various age categories in different proportions. Development of motor capacities is carried out based on adaptation changes in the particular physiological, functional systems and corresponding psychological processes, and is conducted in cooperation with the acquisition of motor skills and habits (Šimonek, 2014).

A rational program of agility development essentially emerges from the knowledge of the factors structuring performance in sports games and combat sports. Sports performance forms a "complex system of factors, which are arranged in a certain way, there exist mutual relations among them and in their entirety, they are manifested in the level of performance" (Dovalil, Choutka, & Svoboda, 2002).

Zatsciorsky (1979 in Šimonek, 2014) underlined the great importance of the knowledge of factors in the structure of sports performance, while pointing to the need to solve the following problems:

1. Which factors underlie the performance in the given sport?
2. What are the mutual relations among these factors?
3. What is the degree of importance of individual factors for the performance in the given sport?
4. The knowledge of the structure of sports performance in time - in various age categories some factors are more important than others, but after time their importance can change. This means that the current level of preparedness and the state of the organism should be evaluated from the point of view of prospective requirements of the model structure of the sports performance. Due to the structural requirements of sports performance and the functional structure of the human organism, there exist two integrated levels on which sports performance evolves.

According to Felix (1997), sports performance is the result of a cooperation of many factors (Fig. 1-4).

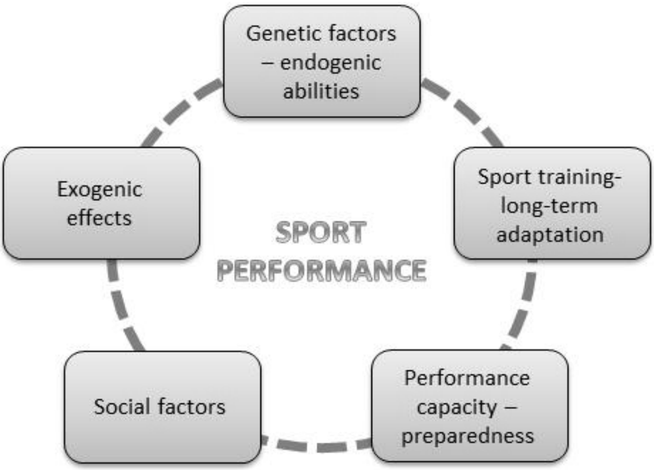


Fig. 1-4 Multifactorial character of sports performance (Felix, 1997).

In the structure of sports performance, we can differentiate the following spheres:

- Genetic predispositions (physiological, psychological and somatic);
- Prerequisites of personality;
- Motor predispositions (motor, conditioning potential);
- Coordination prerequisites and mastery of the sport technique;
- Sport tactics;
- Social environment and conditions.

Top sport poses higher and higher claims on sports preparation, accruing from the necessity of permanent improvement of its contents. Sports games in modern understanding are a highly dynamic and changeable phenomena, and knowledge of their essence requires a deeper analysis and insight into their finest structure (Šimonek, 2014).

Choutka and Dovalil (1991) present the following classification of sport performance – noting that the majority of sport games belong in the group of collective performances - which require a high level of control by the central nervous system as well as analysers For example, anticipation, decision under time pressure, sensory-motor coordination in time and space, claims for a static and dynamic balance, claims for variability and application of the trained potential in the constantly changing conditions of a sports match (Table 1-2). Performance in sports games places a complex set of requirements on players. It consists of a large number of operations and acts, focused on the realization of a certain aim, logically structured according to time and controlled by voluntary processes. The majority of these game activities are realized in non-standard conditions, thus impeding the possibility of their acquisition and improvement in the training process. Similar requirements are also typical in combat sports.

Regarding agility in combat sports, common features of the sports are the kinetic activity of acyclic character and variable intensity of loading (Singh, Sathe, & Sandhu, 2017). Whether you do judo, karate, boxing, wrestling or MMA, your fitness level directly determines how well you perform the skills of the given sport (Scott & Saylor, 2010). The specific skills of individual combat sports require high levels of basic motor abilities, such as flexibility, rhythm, dynamic balance, reaction speed (disjunctive reaction), dynamic strength, speed of action, as well as motor coordination. All of which depend on high levels of the functions of analysers and central nervous system regulation activity. Agility forms a special component of sports performance, which underlies the technical mastery of an athlete. Footwork is very important from the point of view of the result of the match. However, only reactive agility, not the “closed-loop" skill, is the core element of the structure of sports performance in combat ports. This is why we focus on combat sports when characterizing agility performance in sport.

Tab. 1-2 Characteristics of a motor activity in sports games and combat sports (Choutka & Dovalil, 1991 in Šimonek, 2014).

Type of sport perfor-mance	***Sport event***	***Solved task***	***Characteristics of a motor activity***		
			Motoric	***Physiologi-cal***	***Psychologi-cal***
Team sports	Volleyball Soccer Handball Basketball Ice-hockey Field-hockey Water polo.	Overcoming active opponent by individual, group or collective means.	The number of movements or skills is large, complex movement structures, creative coordination, and large variability.	Medium power uptake, regulation of motor activity on quality under the long-term load, cardiovascular and respiratory systems are loaded medium to maximum.	High level of concentration, controlled aggression, creative tactical thinking, the decision under time pressure, anticipation, team thinking and acting, high motivation, high claims for coordination in time and space, earnest attention and fast reaction, claims for dynamic balance.

Combat sport	Boxing Wrestling Judo Fencing Karate Aikido Kendo Sumo Kung-Fu Tae-kwon-do Kickbox	Overcoming active opponent by conditional, technical and tactical means.	The number of movements or skills is large, complex movement structures, often-creative coordination, large variability.	Medium power uptake, regulation of motor activity on quality under the long-term load, cardiovascular and respiratory systems are loaded medium to maximum, aerobic to the anaerobic type of loading with medium to high intensity.	High level of concentration, controlled aggression, creative tactical thinking, the decision under time pressure, anticipation, high motivation, high claims for coordination in time and space, earnest attention and fast disjunctive reaction, claims for dynamic balance.

Although it appears that perceptual decision-making factors can affect competition agility, there is a paucity of scientific data on this relationship. Šimonek (2013a; 2013b) published some results of the research into agility development in soccer, but this is just one of the multiple studies that should be carried out in order to specify the components of the complex ability in sport – agility.

Since, based on the literature analysis, contradictory findings have been reported around the extent of the 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 sports games. For example, Horička, Hianik, and Šimonek (2014), based on the theoretical analysis, carried out measurements of basic factors of speed abilities and agility in 14-17-year-old basketball, volleyball and soccer players (n=56). The results showed that, among the 3 sports games no statistical differences in the level of agility tested by Fitro agility test (basketball - p=0.189; volleyball - p=0.949; soccer - p=0.832) were observed. Spearman rank correlation test showed that no significant correlation (p=0.786; p > 0.05) was found between the results of Fitro agility test and Illinois test measuring speed abilities. The results suggest that agility is not simply one of the speed abilities. Besides simple reaction of speed, acceleration, and deceleration, accompanied by the change in direction of movement comprises, also, of perceptual components determined by the complex reaction to unexpected, changeable stimuli occurring during a sports game.

Factors influencing agility performance

Several factors have been reported as possibly influencing agility performance (Young et al., 2002; Sheppard & Young, 2006a). Cognitive and perceptual factors are considered the discriminating factor in agility performance; however, the majority of research has focused on the physical aspect (Paul, Gabbett, & Nassis, 2016).

Cognitive and perceptual factors distinguish between high- and low-level agility performances (Scanlan, Humphries, Tucker, & Dalbo, 2014).

The technique is considered a component of COD ability (Sheppard & Young 2006a); yet, the amount of empirical evidence is comparatively infrequent. Wheeler and Sayers (2010) have examined the differences in agility running technique between unplanned and pre-planned performance conditions in national and international rugby union players and concluded that the presence of a decision-making element limited lateral movement speed when sidestepping and, as such, the foot-placement patterns differed from pre-planned conditions. Less lateral movement speed during conditions was associated with greater lateral foot displacement at the COD step than in pre-planned conditions.

Physical factors constitute the greatest proportion of total time to complete an agility test. They include strength and power qualities, and functional movement.

Anthropometric factors and change of direction speed

Only a limited amount of research has been carried out that has attempted to find the relationship between anthropometric parameters and performance in the change of direction speed. Theoretically, factors such as body fat and length of body segments can affect agility performance. If we compare two athletes with the same body weight, the one with the higher 20 percentage of body fat will have less active muscle mass contributing to speed requirements on agility performance. Additionally, they will have the larger amount of redundant fat tissue, which will require the bigger production of force per unit of muscle mass in order to perform the given change of speed or direction (Enoka, 2002). Gabbett (2002) tested 159 adolescent (13 – 16 ages) and junior (17 – 18 ages) rugby players. He measured body composition and then put participants through a set of tests including physical ability tests and Illinois agility test. Similar tests were carried out by Meir, Newton, Curtis, Fardell, and Butler (2001) and Reilly, Williams, Nevill, and Franks (2000). Results of all three studies revealed that, in sports like rugby or soccer, players reaching better results in the change of direction speed tests have a lower body fat percentage. No causal (only associative) relationship has been proven. Only one study found a poor correlation (r=0.21) of the above-mentioned variables (Webb & Lander, 1983). We can assume that the low percentage of body fat is a prerequisite of higher performance in the change of direction speed, however, the relationship between these two variables remains unclear. Further anthropometric factors which can potentially influence agility performance include body height, length of extremities, and gravity centre position. Some research studies claim (Cronin, McNair, & Marshall, 2003) that the length of legs affects certain types of movements, such as lunges (typical changes of direction for tennis players). An individual with lower body height should theoretically be able to employ horizontal power faster than the taller athlete is as they do not need so much time to lower the body centre during the preparation for the lateral change of direction). Another factor may be laterality. Testers should take into consideration the effect of laterality of players. In that regard, Rouissi, Chtara, Owen, Chaalali, Chaouachi, Gabbett, et al. (2016) reported that young elite soccer players had a better change of direction performance with the dominant leg vs. the non-dominant leg. Therefore, the difference in time performance between various groups may be influenced by players´ laterality.

Technique

Running technique plays an important role in agility performance (Sayers, 2000). Mainly, the tilt and body gravity centre seem to be crucial, both for optimizing acceleration and deceleration and increasing stability. Stability ensured by gravity centre lowering allows for changing the direction of movement more effectively. Sayers (2000) suggests that, in comparison with sprinting with a higher gravity centre (as it can be seen in the technique of middle- and long-distance runners), the change of direction requires deceleration and postural adjustment (lowering the gravity centre and shortening the stride length). Athletes in sports which demand frequent changes of direction should find a compromise between higher gravity centre running, longer strides, and lowered gravity centre running, or shorter strides. Sayers (2000) also mentions great differences in the specificity of training in athletics and sports games or combat sports, which require fast changes of direction. For example, sprinters, having started from their blocks, keep their eyes set down, while athletes in sports games, where agility plays key role, must visually inspect the whole field and constantly react on the variable changing course of the game. In this case, technique can be also seen during the acceleration phase of the sprint, when a marked incline and gravity centre lowering occurs as in motor tasks containing changes of direction of movement. The further distinction between track and fielders and sport games players is that track and fielders can plan their sprinting action, while soccer players respond by sprinting only during the game which, in many cases, is not pre-planned. For example, during a soccer game, approximately 1,300 changes of movements are undertaken in off-the-ball conditions; players perform over 700 turns and swerves at different angles throughout the game (Stolen, Chamari, Castagna, & Wisloff, 2005).

Besier, Lloyd, Ackland, and Cochrane (2001) investigated what role technique plays at onset speed in tasks containing changes of direction of movement. They examined the loading of the knee joint in planned and unplanned changes of direction. When athletes had to change direction in reaction to a light stimulus, the action of force in the knee joint increased. It is assumed from the study that unplanned changes of direction of movement brought up by a reaction to stimulus increases the action of force in the knee joint more than the changes of direction planned.

CHAPTER TWO

REACTIVE VERSUS PRE-PLANNED AGILITY

Sports games performance is characterized by high-speed actions, while athletes 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, the speed of whole-body change of direction, and agility represent the basic components of sports performance mainly in sports 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 sports researchers. 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 manoeuvres successfully will depend on other factors such as visual processing, reaction time, perception and anticipation. Speed and agility in team sports represent complex psychomotor skills (Verkhoshansky, 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 and can, therefore, be divided into several phases: acceleration, maintenance of maximum speed and deceleration (Plisk, 2008). Agility is most commonly 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, which is an important component of this trait, amongst others. The basic definition of agility is too simplistic because it is now thought to be much more complex, involving 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 in 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 a significant correlation between straightforward sprinting and agility in two different groups of Australian football players. Nor was there any correlation between agility, acceleration speed, and maximal speed found in the group of 106 Australian football players who were assessed for 10m sprint (acceleration), flying 20m 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, and Pryor (2001) proved, through their research, that if agility and speed abilities are connected with the performance of sport specific skill, inter-correlation decreases even more. This can also be caused by the fact that training methods for their development are specific to each of the types of speed abilities, thus minimum transfer of qualities between them occurs (Young, McDowel, & Scarlett, 2001).

Traditionally agility has been defined as “the ability to change direction rapidly” (Bloomfield, Ackland, & Elliot, 1994; Mathews, 1973) “the ability to change direction rapidly and accurately” (Barrow & McGee, 1971), “whole body change of direction” as well as “rapid movement and direction change of limbs” (Baechle, 1994; Draper & Lancaster, 1985). However, this does not take into account that most changes of direction in sport are in response to a sport-specific stimulus. Sheppard and Young (2006a) stated that a definition of agility should not only recognize the physical and technical skills involved, but the cognitive processes as well. However, agility is typically tested and trained by using set drills that require an athlete to navigate around a pre-planned course as quickly as possible (Draper & Lancaster, 1985; Semenick 1990), with these pre-planned drills being closed-skill drills with no response to a stimulus. Commonly employed agility tests, in fact, assess only the change of direction performance. This stipulates that there must be some element of reaction and/or decision-making in any true assessment of agility. Some change of direction tests incorporate simple reaction cues, such as response to lights or similar. However, this does not represent a valid measure of the game-related information-processing and decision-making factors that contribute to team sports agility performance (Sheppard & Young, 2006a). Agility is now regarded to be more complex and as incorporating neuropsychological factors such as anticipation, intuition, sensory processing, and decision making with such physiological factors as response time, acceleration and maximum speed, change of direction speed and mobility. Moreover, these factors interact with each other to varying degrees, dependent upon the sport-specific context. It is now commonly accepted that visual cue processing, anticipation, and reaction time are all important to agility performance in team sports (Veale, Pearce, & Carlson, 2010).

Lockie, Jeffriess, McGann, Callaghan, and Schultz (2014) try to verify, in their research, the assumption that planned and reactive agility are different athletic skills, also in basketball players. Results of this study reemphasized that planned and reactive agility are separate physical qualities. Reactive agility discriminated between semi-professional and amateur basketball players, while planned agility did not.

Horička, Hianik, and Šimonek (2014) carried out measurements with the aim of finding out the correlation between agility and the ability to simply react, accelerate, decelerate and change the direction of movement. They presumed that there was no significant correlation between the results of two tests – Fitro Agility Check (FAC) and Illinois Test executed by young male soccer, basketball and volleyball players (n=56; M_{age} = 15.78 years, age range: 14 – 17 years) randomly recruited from the local basketball (V_{10}), volleyball (V_{13}) and soccer (V_{33}) teams in Nitra. Authors of the research expected that the performance of players of different sports games would not be significantly different in the test Fitro Agility Check. Fig.2-1 shows the different variability of values in the observed groups. The highest variance was registered in the values of volleyball players, followed by soccer, while the lowest variance was observed in basketball players. Authors presume that this fact could be induced by scattered extreme values mostly in volleyball and basketball players.

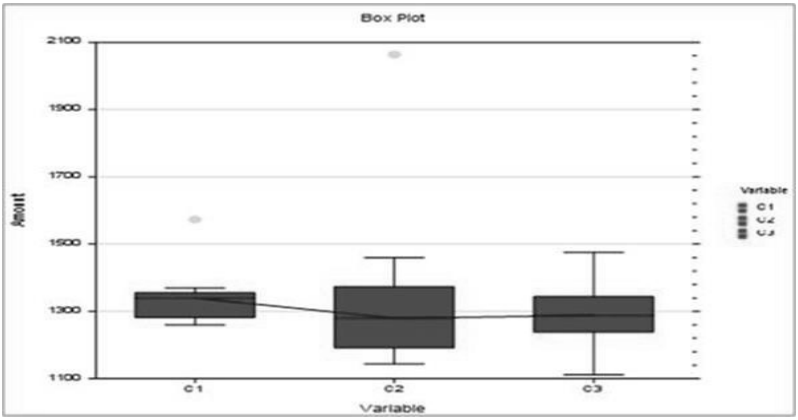


Fig. 2-1 Variance of performances in Fitro agility check (FAC).

In the case of the comparison between the values in FAC in the groups of basketball and volleyball (F-test for variance), the value p=0.000323 was found. Since p<0.05, t-test with unequal variances was used (Table 2-1). In the remaining two cases, when comparing the performance of basketball and soccer players (p= 0.51767; Table 2-2) or volleyball and soccer players (p 4.80991; Table 2-3), the value was higher than p> 0.05 so it was necessary to use t-test with equality of variance.

Table 2-1 Two-sample F-test for variance (basketball – volleyball).

	basketball	*volleyball*
Median	1339.30	1333.25
Variance	6435.52	56907.26
n	13	13
Difference	12	12
F	0.1130	
P(F<=f) (1)	0.00032	p< 0.05

Table 2-2 Two-sample F-test for variance (basketball – soccer)

	basketball	*soccer*
Median	1339.30	1286.10
Variance	6435.52	6525.91
N	13	33
Difference	12	32
F	0.9861	
P(F<=f) (1)	0.51767	p> 0.05

Table 2-3 Two-sample F-test for variance (volleyball – soccer)

	volleyball	*soccer*
Median	1333.25	1286.10
Variance	56907.26	6525.91
N	13	33
Difference	12	32
F	8.720	
P(F<=f) (1)	4.809	p> 0.05

The following findings were taken from the results:

a) Zero hypothesis could be accepted so basketball and volleyball players did not statistically differ in the overall level of performance in the test Fitro agility check /p = 0.931> 0.05/.
b) Zero hypothesis could be accepted so basketball and soccer players did not statistically differ in the level of performance in the test Fitro agility check /p = 0.0501> 0.05/. In this case, the p-value is on the border of the opposite interpretation of the relationship between the performances of both groups.
c) Zero hypothesis could be accepted so soccer and volleyball players statistically did not differ in the level of overall performance in the test Fitro agility check /p = 0.3173 > 0.05/.

T-test for two samples showed that players of basketball, volleyball, and soccer did not have a statistically significantly different level of reactive agility (FAC). With the exception of the performances of basketball and soccer players, this statement is unequivocal. The character of the movement, mainly its reaction and speed-strength determinants are likely to be similar in all observed samples since no significant differences were found between players (Tables 2-4, 2-5, and 2-6).

Table 2-4 Two-sample t-test with unequal variances (basketball – volleyball).

	basketball	*volleyball*
Median	15.65	15.63
Variance	6435.522	56907. 26
t Stat	0.086782	
P(T<=t) (1)	0.465996	
t crit (1)	1.75305	
P(T<=t) (2)	0.931993	p> 0.05
t crit (2)	2.13145	

Table 2-5 Two-sample t-test with unequal variances

	basketball	*soccer*
Median	15.65	16.44
Variance	6435.522	6525.91
t Stat	2.015004	
P(T<=t) (1)	0.02502	
t crit (1)	1.68023	
P(T<=t) (2)	0.050149	p > 0.05
t crit (2)	2.015368	