Introduction

The phenomenon of functional asymmetry of a man has been studied by physiologists, psychologists, clinicians, sports teachers and other specialists for a long time. This study began in 1861 when Broca discovered the centre of oral motor in the left brain (Broca, 1861a, 1861b). Nowadays, the problem of functional asymmetry keeps attracting interest among scientists. This statement can be proved by many publications devoted to the study of genetic and sociocultural factors of functional asymmetry formation (Pozharskaya, 1996; Berdichevskaia & Gronskaya, 2009; Moskvina & Moskvin, 2010; Chermit et al., 2014; Kovalchuk, 2015; Moskvin & Moskvina, 2015) and to the assessment of its influence on the various activities of a man including his physical work efficiency (Chibis, 1997).

Functional asymmetry manifests in different systems of a human organism. There are main types of functional asymmetry: motor, sensory and psychic (Bragina & Dobrokhotova, 1981, p. 11). Sports teachers are specifically interested in motor asymmetry, which influences technical characteristics in a chosen sport. In this paper motor asymmetry is regarded as a total of characteristics of function inequality of arms, legs, sides of the body and face in formation of the general motor behaviour and its expressiveness (Bragina & Dobrokhotova, 1981, p. 11). “Motor asymmetry” as an object of study started to develop after the motor cortex was discovered by Fritsch and Hitzig in 1870. Then it was observed that the movement of the body can be caused by the electrical stimulation of the brain cortex (Fritsch & Hitzig, 1870).

Inequality of functions of arms and legs has been marked by Humphrey (1861), Biervliet (1897), Stier (1911), Masyuk (1939) and Potseluev (1960). The mentioned scientists thought this phenomenon to be inborn. However, different results were obtained by Komai and Fukuoka (1934) and also by Ambarov (1969) in their researches: in jumping 93-96 % of the surveyed children used the left leg as dominant, while in hitting the ball 90-98 % of them used the right leg as dominant. Therefore, whether the leg will be dominant or not depends on the function it performs in the particular situation: supporting function or swinging function (Il’in, 2001). Generally speaking, lateral phenotype is the factor which determines the success of adaptation to exercise load connected with the necessity to realise motor programmes in a short time (Fomina, 2006).

It is known that functional asymmetry can be taken into account when choosing the methods of teaching technical activities with suitable predominance of exercises oriented to the particular system of information perception (attention, perception, thinking, imagination, memory) (Anisimov, 2011; Korobeynikov et al., 2014). This means that functional asymmetry can influence the quality of performing the motor action and the sports result, therefore it is necessary to take it into account in applying methods of sportsmen’s training.

This research aims at analysing the influence of functional asymmetry on the sports result in various sports and presentation of the approaches providing a means of improving the sports result using functional asymmetry in athletic performance.

1. The influence of functional asymmetry on the sports result in various sports
The results of numerous researches show that functional asymmetry can have both positive and negative influence on the sports result. For example, some authors point at negative influence of functional asymmetry in some sports where simultaneous extremities motion performance or the symmetric motion performance is required. In high diving due to asymmetry of lower extremities during thrusting off the prop one of the legs takes off earlier and consequently the asymmetric lift takes place which produces negative influence on the technique of high diving performance (Antsyperov & Ivanov, 2013). Chivil notes that in rhythmic gymnastics performing the exercises which help to symmetrically develop active and passive flexibility of lower extremities leads to getting higher difficulty score (Chivil’ & Stepanova, 2014). In general, in such precise sports as rhythmic gymnastics or acrobatics the high level of sensorimotor symmetry is the indicator of economical energy output (Litvinenko et al., 2015). Pronounced asymmetry observed in keeping vertical position without eye control (Zamchiy et al., 2014) is undesirable and can lead to weight decetration such as in jumping in baseball (Bailey et al., 2015). In canoeing decrease of coefficient of upper and lower extremities asymmetry which is manifested in inadequate efforts applied to the blade and footrest leads to speed increase (Bryukhanov & Kornilov, 2014).

Positive influence of functional asymmetry on the sports result is also described in modern literature. For example, swimmers’ arms asymmetry influences directly the length, strength and quality of a stroke. The quality of the dominant arm stroke while breathing in is more effective than while breathing to the subdominant side. It means that it is essential to identify the arms motor asymmetry in the first training classes and take it into account during teaching crawl stroke (Gramatikopolo, 2011, p. 10). In canoeing increase of asymmetry of lumbar spine curve in the frontal plane promotes the speed increase (Rynkiewicz et al., 2013, p. 42). In the same time such pathology is the result of the physical exercise in this sport. In alpine skiing sportsmen perform the two-step more effectively if they push off to the dominant leg side. Furthermore, this effectiveness raises together with the increase of motor action intensity of a sportsman (Stöggli et al., 2013, p. 1574). In the beginning of training left-handed swimmers can have higher effectiveness of breast-stroke and crawl stroke, because it was observed that the left-handed people unconsciously choose simultaneous structure of move, whereas the right-handed people prefer to move legs alternately – both in crawl and back crawl (Lavrén’eva, 2015, p.21; Lavren’t’eva, 2016, p. 131). Hockey players with right lateral preference exceed other players in coordination (Vas’il’ev et al., 2014, p.98). Basketball players with left-side asymmetry profile have better coordination abilities than their teammates (Zagrevskaya, 2016, p. 32). The results of St. Petersburg Greco-Roman wrestlers performance during Russian championship in 2015 testify the positive effect of the training technique individualisation by means of accentuated perfection of the stronger sides of the athletes (Apoiko, 2015, p.19).

It is worthwhile noting that some scientists who investigated the influence of functional asymmetry on the sports result point out the positive influence of asymmetry in some particular sports, whereas the others describe the negative influence of asymmetry in the same kinds of sport. In this connection, in one and the same sport they can use methods focused both on asymmetry flattening and accentuated perfection of the stronger sides. For example, Gronskaya (2014, p. 76) believes that in jumping over barriers it is important to use asymmetry as an advantage and put exercise stress on the supporting and swinging legs with account of the target goal which motor action performed by an extremity has. Bobina (2007, p. 30), by contrast, points out to the result growth in the same sport by using training methods focused on the strength asymmetry flattening of the lower extremities. The results of Semenyukov’s research in soccer (2009, p. 88) show that devoting 15-20 % more of the training time to the work with the subdominant leg promotes lower extremities asymmetry flattening and enhances quickness, agility and technical skill. However, it is believed that having players with “uncomfortable” dominant side in a team increases the effectiveness of playing (Remeeva, The same phenomenon is noted with wrestlers, boxers, tennis players and fencers (Chermit, 1992; Sologub & Taymazov, 2000). The results of the conducted analysis and the necessity for flattening/enhancing of asymmetry depending on the sport, indicator or the motor action are presented in the Table 1.

<table>
<thead>
<tr>
<th>№</th>
<th>Sport</th>
<th>Indicator/motor action</th>
<th>Necessity for flattening (↓) /enhancing (↑) of asymmetry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Highdiving</td>
<td>Thrusting off the prop with lower extremities(Antyperov &amp; Ivanov, 2013)</td>
<td>↓</td>
</tr>
<tr>
<td>2</td>
<td>Rhythmic gymnastics</td>
<td>Performing precisetechnical motor actions and technical aesthetic motor actions (Chivil’ &amp; Stepanova, 2014)</td>
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<tr>
<td></td>
<td></td>
<td>(Litvinenko et al., 2015)</td>
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<tr>
<td>4</td>
<td>Baseball</td>
<td>Body position maintaining in jumping (Bailey et al., 2015)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Canoeing</td>
<td>Efforts applied to the blade and footrest (Bryukhanov &amp; Kornilov, 2014)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Lumbar spine curve in the frontal plane (Rynkiewicz et al., 2013)</td>
<td></td>
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<tr>
<td>6</td>
<td>Alpine skiing</td>
<td>Efficiency of pushing off in performing two-step (Stöggl et al., 2013)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Swimming</td>
<td>Selection of the efficient swimming style (Gramatikopolo, 2011)</td>
<td></td>
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<tr>
<td>8</td>
<td>Hockey</td>
<td>Coordination ability (Vasil’ev et al., 2014)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Basketball</td>
<td>Coordination ability (Zagrevskaya, 2016)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Hurdling</td>
<td>Strength asymmetry of lower extremities (Bobina, 2007)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use of swinging and supporting leg (Gronskaya et al., 2014)</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Soccer</td>
<td>Efficiency of ball handling (Semenyukov, 2009)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Boxing</td>
<td>Efficiency of rivals with “uncomfortable” dominant side (Chermit, 1992; Sologub &amp; Taymazov, 2000)</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Tennis</td>
<td>Efficiency of rivals with “uncomfortable” dominant side (Chermit, 1992; Sologub &amp; Taymazov, 2000)</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Fencing</td>
<td>Efficiency of rivals with “uncomfortable” dominant side (Chermit, 1992; Sologub &amp; Taymazov, 2000)</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Greco-Roman wrestling</td>
<td>Efficiency of rivals with “uncomfortable” dominant side (Apoyko, 2015)</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>10↑; 7↓</td>
<td></td>
</tr>
</tbody>
</table>

The results of the analysis of functional asymmetry influence on the sports result in various sports show that different indicators indirectly affecting the efficiency of motor action performance and sport result in whole are taken into account. Functional asymmetry can have both positive and negative influence in one and the same sport depending on the aim of the performed motor action and indicator involved in result progress. One extremity can be dominant in one motor action and subdominant – in the other. A right-handed person can use his or her left hand as dominant for performing particular motor actions (Gutnik & Kobrin, 2007, p. 70).

2. Techniques, methods and means of training which take into account functional asymmetry

There are various means and methods used in training techniques: local weighting of subdominant leg, redistribution of loads among extremities, doing static exercises, use of visual feedback, doing exercises from the team sports and performing various throws to the given distance, height and exactitude.

Chikurov et al. (2016, p. 1288) have found out that implementing targeted asymmetric power action (local weighting of subdominant leg) into the sprinters training technique leads to controlled destabilisation of habitual motor skill and change of rhythmic structural characteristics of running, which results in overcoming the “speed barrier” of the sportsmen. It is also known that one can enhance sports result in training process of various sports by using the method of redistribution of loads between legs which consists in increasing the load of subdominant leg by 15-20% (Anisimov, 2011, p. 14, 28; Bryukhanov & Kornilov, 2014, p. 223; Gronskaya et al., 2014, p. 29; Bobina, 2007, p. 87; Chivil’ & Stepanova, 2014, p. 188; Kostyuchenko et al., 2008, p. 56; Blinov & Semenyukov,
2013, p. 242). In weightlifting the asymmetry flattening of lower extremities can be attained by doing static squats at a knee angle of 120° and 90° (Bazyler et al., 2014, p. 8) or by using the outward weighting – barbell (Kostyuchenko, 2008, p. 63; Shestakov et al., 2010, p. 177). Ezhova (2013) points to successful asymmetry flattening of the cooners’ efforts applied to the blade by paddling in training simulators with constant self-regulation of amount of subdominant arm applied efforts to the index of dominant arm applied efforts which are demonstrated on the monitor (visual feedback). Fetisova (2016, p. 191) notes that doing exercises from various team sports (volleyball, basketball, soccer) helps military men to use subdominant arm more often and to shift this skill to their professional activity so that it enhances training efficiency and battle tasks performance. Action games have positive influence on the lower and upper extremities asymmetry flattening as evidenced by the experiment with 7-year old children. The experiment involved alternation of volleyball, basketball and soccer exercises of left and right legs and arms (Ayrapet’yants & Isroilov, 2015, p. 19). Kletsov (2015, p. 29) points to the successful asymmetry flattening of the upper extremities by throwing missiles (skipping rope, hula hoop, ball, Indian club) to the given height and distance which increases stability and technique variability.

The means and methods of training stated above are aimed at functional asymmetry flattening. Training methods, techniques and means used for enhancing functional asymmetry on a system level have not been found in the well-known scientific literature. This brings us to the conclusion that functional asymmetry develops not purposefully, but indirectly – through the training process directed at achieving the sports result.

3. **Functional asymmetry influence on the sportsman condition during the long-term training process**

Doctors in sports medicine claim that asymmetry developed in the long-term training process negatively influences the human health condition and causes injuries. With the help of video analysis of biomechanics of rugby players movements Gore et al. found out that asymmetry flattening of lower extremities can ease the pain in the pelvic area (Gore et al., 2014, p. 240). Abramova studied spatial position of the torso, pelvis and feet of highly qualified male sportsmen in various sports and defined main abnormalities in locomotor system, such as change of body posture, body twist in relation to pelvis, tonus disbalance of paired sets of muscles of the torso and extremities (Abramova, 2013, p. 64). The analysis of skiers fitness shape showed that the sportsmen complained of the pain to the right and left of the sciatic nerve; right-handed skiers had pain in the area of the right hypochondrium depending on the type of the skier stance (Plotnikov & Mar’yanovskiy, 2007, p. 43). According to the data from Poluektov’s research (Poluektov, 2013, p. 122), the vast majority of the sportsmen specializing in the middle-distance race have various abnormalities in locomotor system such as pelvic position asymmetry, transverse platypodia, discernible asymmetry of back muscles and lower extremities tonus, which leads to delayed recovery process after training loads. The stomatoscopic study of fencers and tennis players has shown that the length of the sportsmen’s involvement in sport influences the development of locomotor system deformation in a following way: 2-3 years – nonpersistent corrective deformations in the sagittal plane, 3-5 years – persistent and nonpersistent deformations in both planes, over 5 years – spine pathology which is difficult to correct (Sedochenko, 2015, p. 19). Kickboxers (from the second-class sportsmen to the masters of sport) have chronic abnormality of functionally significant set of muscles in the form of tonus increase of upper part of trapezoid, inferior oblique, scalar, pectoral and iliopsoas muscles and tonus decrease of abdominal muscles, middle and lower blade muscles, which leads to muscle imbalance (Shevtsov, 2012, p. 30). Knapik et al. examined 138 female athletes and found out that if the difference in strength in the right and left extremity is more than 15%, then it leads to higher risk of injury (Knapik et al., 1991).

In this regard it is essential in the long-term training process under the conditions of increasing physical activity or repeated asymmetric force impact on the locomotor system to hold rehabilitation activity aimed to correct the diagnosed abnormalities with account of individual differences of sportsmen.

4. **Stabilization of the individual asymmetry profile and the search of sports result growth**

It has been established that during the long-term training process the degree of functional asymmetry increases together with the sportsman’s qualification growth and establishes oneself in a fully developed individual asymmetry profile (IAP) of a sportsman according to the specific character of physical activity in a particular sport (Kozlov et al., 2005, p. 26; Berdichevskaya & Gronskaya, 2009, p. 64; Rynkievicz et al., 2013, p. 51; Antsyperov & Ivanov, 2013, p. 4; Khachaturova, 2015, p. 238; Moskvin & Moskvina, 2015, p. 59). Table 2 shows the lateral preferences of qualified sportsmen in some sports.

<table>
<thead>
<tr>
<th>№</th>
<th>Sport</th>
<th>Lateral preferences of qualified sportsmen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Arm</td>
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</tbody>
</table>

Table 2 – Lateral preferences of qualified sportsmen in some sports
<table>
<thead>
<tr>
<th>No.</th>
<th>Sport</th>
<th>R</th>
<th>LR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sport tourism</td>
<td>R(Aganyants et al., 2004, p. 22)</td>
<td>LR(Aganyants et al., 2004, p. 22)</td>
</tr>
<tr>
<td>2</td>
<td>Basketball</td>
<td>R(Ignat’eva &amp; Maydokina, 2016, p. 66)</td>
<td>L(Ignat’eva &amp; Maydokina, 2016, p. 66)</td>
</tr>
<tr>
<td>3</td>
<td>Weightlifting</td>
<td>R(Bazyler et al., 2014, p. 8)</td>
<td>LR(Bazyler et al., 2014, p. 8)</td>
</tr>
<tr>
<td>4</td>
<td>Volleyball</td>
<td>R(Aganyants et al., 2004, p. 22)</td>
<td>R(Aganyants et al., 2004, p. 22)</td>
</tr>
<tr>
<td>5</td>
<td>Boxing</td>
<td>R(Aganyants et al., 2004, p. 22)</td>
<td>L(Aganyants et al., 2004, p. 22)</td>
</tr>
<tr>
<td>6</td>
<td>Swimming</td>
<td>L(Gramatikopolo, 2011, p. 75)</td>
<td>L(Gramatikopolo, 2011, p. 75)</td>
</tr>
<tr>
<td>7</td>
<td>Handball</td>
<td>L(Aganyants et al., 2004, p. 22)</td>
<td>L(Aganyants et al., 2004, p. 22)</td>
</tr>
<tr>
<td>8</td>
<td>Soccer</td>
<td>L(Aganyants et al., 2004, p. 22)</td>
<td>R(Ignat’eva &amp; Maydokina, 2016, p. 66)</td>
</tr>
<tr>
<td>9</td>
<td>Acrobatics</td>
<td>L(Aganyants et al., 2004, p. 22)</td>
<td>R(Aganyants et al., 2004, p. 22)</td>
</tr>
<tr>
<td>10</td>
<td>Wrestling</td>
<td>L(Aganyants et al., 2004, p. 22)</td>
<td>L(Aganyants et al., 2004, p. 22)</td>
</tr>
<tr>
<td>11</td>
<td>Cycling</td>
<td>-</td>
<td>LR(Aganyants et al., 2004, p. 22)</td>
</tr>
<tr>
<td>12</td>
<td>Armwrestling</td>
<td>R(Berdicevskaya et al., 2007, p. 63)</td>
<td>-</td>
</tr>
<tr>
<td>14</td>
<td>400-meter hurdles</td>
<td>R(Gronskaya et al., 2014, p. 76)</td>
<td>R (Gronskaya et al., 2014, p. 76)</td>
</tr>
<tr>
<td>17</td>
<td>Table tennis</td>
<td>R(Nabieva &amp; Mendzheritskiy, 2015, p. 19)</td>
<td>R(Nabieva &amp; Mendzheritskiy, 2015, p. 19)</td>
</tr>
</tbody>
</table>

- L – motor actions are performed mostly with the left extremity;
- R – motor actions are performed mostly with the right extremity;
- LR – motor actions can be performed both with the left and right extremity;
- «-» – the extremity preference has not been studied.

The analysis of the lateral preferences of qualified sportsmen in various sports shows that the experiment results of dominant/subdominant extremity determination can differ in the works of the researchers of one and the same sport. It can be explained by the fact that the tests with different character of the performed motor action were used for determination of the extremity dominance. That means extremity dominance depends on the function this extremity performs.

The rates of motor skills, physical fitness and laterality formation are closely interrelated, determined by one and the same mechanisms and are derivatives of the genetic properties realisation (Chernit, 2004, p. 35). During the long-term training process the lateral preference of a sportsman becomes stable and IAP takes a well-balanced form, which is dictated by the peculiar features of physical exercises in the chosen sport when using the training methods with no regard for asymmetric features of a man. In the course of sports result growth together with sportsmen’s IAP stabilization the motor skill is formed and the movement stereotype becomes stable, which is represented in Fig. 1, damped and flattening sine curve on reaching t. This IAP alteration chart is supported by results of Trishin’s experiment (Trishin et al., 2015, p. 10), which was conducted with the highly qualified sportsmen specialized in basketball and table tennis. These results point to the sportsmen lateral preference fixation in accordance with the character of physical exercises in the chosen sport.

Formed motor skills which are a positive phenomenon in whole at the same time have negative result in the form of the stop of sports result growth (Filin, 1964; Petrovskiy, 1978). In many cases the movement stereotype development and consequently the stop of sport result growth take place within the conditions of early specialisation of the young sportsmen when they perform one and the same type of physical exercise during the long-term training process. However, as the children’s IAP variability at an early age is higher than the adults’ IAP (Aganyants et al., 2004, p. 23; Petrova, 2006, p.13), it is necessary to take the asymmetric features of a man into account from the very beginning of sportsmen’s training. It can help to stop the early skill development and provide the opportunity for a sustained and incremental growth of sports result whereas the classical training approaches, which do not take IAP into account, or one-sidedly oriented approaches which take the asymmetry (flattening or enhancing only) into account can not provide the stable progress in sports result. Fig. 1 shows how the sports result can progress during longer time t due to the IAP variability maintenance.
Fig. 1 – Hypothetic sports result (RES) and individual asymmetry profile (IAP) as training process time functions according to the data (Chikurov et al., 2016, p. 1288); t₁ – skill stabilization time with no regard for IAP; t₂ – skill stabilization time with regard for IAP in a training process.

The case with the sprint athletes (Chikurov et al., 2016, p. 1288) described above proves that the use of training technique with regard for asymmetric features promotes sports result progress.

**Conclusions**

Functional asymmetry of a man can have both positive and negative influence on the the sports result. In sports where asymmetry is a limiting factor the training techniques aimed at asymmetry flattening are used. Failing this the perfection of the sportsman’s strong points takes place. In the beginning of the long-term training process sportsmen have a high IAP variability. However, together with the qualification growth the sportsmen’s lateral preference and IAP become stable.

In addition, together with sportsmen’s IAP stabilization the motor skill development takes place, the movement stereotype becomes stable, which leads to the stop of the sports result growth. Under the conditions of an early sportsmen’s specialisation the skill formation and consequently the stop of the sports result growth often take place unreasonably early. The analysis of the techniques, methods and means of training in various sports allows us to make the following conclusion: functional asymmetry is a biological phenomenon which helps to avoid early motor skill formation. The asymmetric features of a man should be taken into account in training techniques at all stages of the long-term training process, starting with the early motor action training when sportsmen have a high IAP variability. This can help to promote the sports result growth.

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