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Original Article

Functional asymmetry and the sports result

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Abstract:
This paper investigates functional asymmetry of a man as a biological phenomenon which accompanies sports result within the scope of well-known literature data and the authors' personal study results. In the course of the performed summary of research findings the authors assess the influence of functional asymmetry on sports result in some sports and illustrate the well-known training techniques, methods and means which take into account functional asymmetry. They also review the influence of functional asymmetry on the sportsman's condition during the long-term training process and systemize the lateral preferences of qualified sportsmen in some sports. The approaches considering functional asymmetry in the training process and allowing long-term positive dynamics of sports result are examined and illustrated in this paper.
Key words: functional asymmetry; individual asymmetry profile; asymmetry flattening; motor skill stabilization

Introduction

The phenomenon of functional asymmetry of a man has been studied by physiologists, psychologists, clinicians, sports teachers and other specialists for a long lime. 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; Berdichevskaya & 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.

Material & methods

Theoretical basic

The influence of functional asymmetry on the sports result in various sports

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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 (Antsyperovn & 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 decentration 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 (Stöggl 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 (Lavren't'eva, 2015, p.21; Lavren't'eva, 2016, p. 131). Hockey players with right lateral preference exceed other players in coordination (Vasil'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 (Apoyko, 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 1 - Necessity for flattening/enhancing of asymmetry in some sports

№	Sport	Indicator/ motor action	Necessity for flattening (↓) /enhancing (↑) of asymmetry
1	High diving	Thrusting off the prop with lower extremities (Antsyperov & Ivanov, 2013)	↓
2	Rhythmic gymnastic	Performing precise technical motor actions and technical aesthetic motor actions (Chivil' & Stepanova, 2014)	↓
		Body position regulation in solving the stability tasks (Litvinenko et al., 2015)	↓
4	Baseball	Body position maintaining in jumping (Bailey et al., 2015)	↓
5	Canoeing	Efforts applied to the blade and footrest (Bryukhanov & Kornilov, 2014)	↓
		Lumbar spine curve in the frontal plane (Rynkiewicz et al., 2013)	↑
6	Alpine skiing	Efficiency of pushing off in performing two-step (Stöggl et al., 2013)	↑

7	Swimming	Selection of the efficient swimming style (Gramatikopolo, 2011)	↑
8	Hockey	Coordination ability (Vasil'ev et al., 2014)	↑
9	Basketball	Coordination ability (Zagrevskaya, 2016)	↑
10	Hurdling	Strength asymmetry of lower extremities (Bobina, 2007)	↓
		Use of swinging and supporting leg (Gronskaya et al., 2014)	↑
11	Soccer	Efficiency of ball handling (Semenyukov, 2009)	↓
12	Boxing	Efficiency of rivals with "uncomfortable" dominant side (Chermit, 1992; Sologub & Taymazov, 2000)	↑
13	Tennis	Efficiency of rivals with "uncomfortable" dominant side(Chermit, 1992; Sologub & Taymazov, 2000)	↑
14	Fencing	Efficiency of rivals with "uncomfortable" dominant side (Chermit, 1992; Sologub & Taymazov, 2000)	↑
15	Greco-Roman wrestling	Efficiency of rivals with "uncomfortable" dominant side (Apoyko, 2015)	↑
TOTAL			10↑; 7↓

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 conoers' 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.

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, scalene, 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).

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; Rynkiewicz 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 2 – Lateral preferences of qualified sportsmen in some sports

№	Sport	Lateral preferences of qualified sportsmen	
		Arm	Leg
1	Sport tourism	R (Aganyants et al., 2004, p. 22)	LR (Aganyants et al., 2004, p. 22)
2	Basketball	R (Ignat'eva & Maydokina, 2016, p. 66)	L (Ignat'eva & Maydokina, 2016, p. 66)
3	Weightlifting	R (Bazyler et al., 2014, p. 8)	LR (Bazyler et al., 2014, p. 8)
4	Volleyball	R (Aganyants et al., 2004, p. 22)	R (Aganyants et al., 2004, p. 22)
5	Boxing	R (Aganyants et al., 2004, p. 22)	L (Aganyants et al., 2004, p. 22)
6	Swimming	L (Gramatikopolo, 2011, p. 75)	L (Gramatikopolo, 2011, p. 75)
7	Handball	L (Aganyants et al., 2004, p. 22)	L (Aganyants et al., 2004, p. 22)
8	Soccer	L (Aganyants et al., 2004, p. 22)	L(Aganyants et al., 2004, p. 22); R (Ignat'eva & Maydokina, 2016, p. 66)
9	Acrobatics	L (Aganyants et al., 2004, p. 22)	R (Aganyants et al., 2004, p. 22)
10	Wrestling	L (Aganyants et al., 2004, p. 22)	L (Aganyants et al., 2004, p. 22)
11	Cycling	-	LR (Aganyants et al., 2004, p. 22)
12	Armwrestling	R (Berdichevskaya et al., 2007, p. 63)	-
13	Shooting sports	R (Butinov, 2011, p. 266; Khachaturova, 2012, p. 18)	R (Butinov, 2011, p. 266; Khachaturova, 2012, p. 18) LR (Khachaturova, 2015, p. 239)
14	400-meter hurdles	R (Gronskaya et al., 2014, p. 76)	R (Gronskaya et al., 2014, p. 76)
15	Long jump	R (Aleksanyants et al., 2004, p. 9; Kudryashova et al., 2014, p. 187)	R (Aleksanyants et al., 2004, p. 9; Kudryashova et al., 2014, p. 187)
16	Mixed martial arts	R (Taymazov & Bakulev, 2006, p. 76)	R (Taymazov & Bakulev, 2006, p. 76)
17	Table tennis	R (Nabieva & Mendzheritskiy, 2015, p. 19)	R (Nabieva & Mendzheritskiy, 2015, p. 19)

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.

Results

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 (Chermit, 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_1. 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_2 due to the IAP variability maintenance.

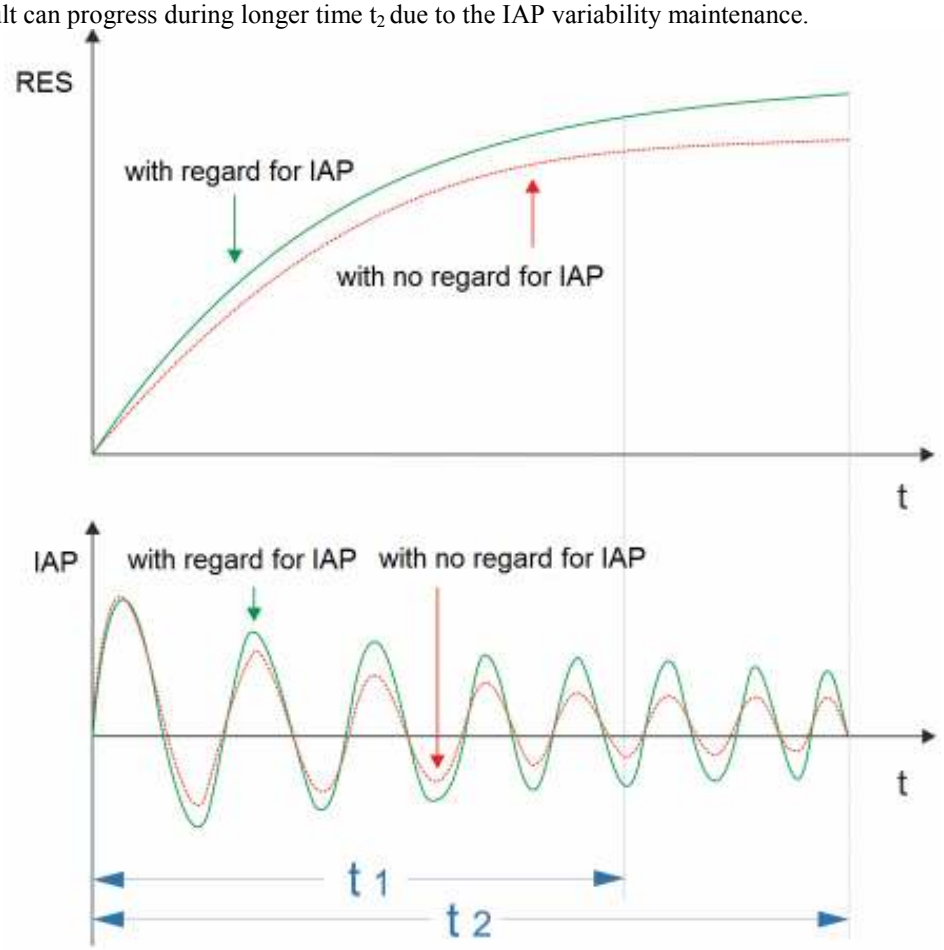

Fig. 1 – Hypothetic sports result (RES) and individual asymmetry profile (IAP) as training process time functions according to the data (Chikurov et al., 2016, p. 1288): t_1 – skill stabilization time with no regard for IAP: t_2 - skill stabilization time with regard for IAP in a training process

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.

Dicussion

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).

The means and methods of training 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.

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.

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.

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.

References:

Abramova, T.F., Nikitina, T.M., Kochetkova, N.I. & Krasnikov, V.A. (2013) Osobennosti prostranstvennogo polozheniya tulovishcha, taza i stop u vysokokvalifitsirovannykh sportsmenov-muzhchin razlichnykh vidov sporta *Vestnik sportivnoy nauki.* 5. pp. 58–65.

Aganyants, E.K. et al. (2004) Funktsional'nye asimmetrii v sporte: mesto, rol' i perspektivy issledovaniya *Teoriya i praktika fizicheskoy kul'tury.* 2004. 8. pp. 22–24.

Aleksanyants, G.D. et al. (2004) Funktsional'nye asimmetrii v sporte: mesto, rol' i perspektivy issledovaniya [Functional asymmetries in sports: the place, role and prospects of research*]. Teoriya i praktika fizicheskoy kul'tury – Theory and Practice of Physical Culture.* 2004. 8. pp. 22–24.

Ambarov, E.Kh. (1969) Funktsional'naya asimmetriya nizhnikh konechnostey i podgotovka podrostkov i yunoshey, zanimayushchikhsya legkoy atletikoy. Abstract of Physical Culture Science Candate Dissertation. Moscow.

Anisimov, M.P. (2011) Obuchenie tekhnicheskim deystviyam v smeshannykh edinoborstvakh s uchetom mezhpolusharnoy asimmetrii. *Zdorov'e – osnova chelovecheskogo potentsiala: problemy i puti ikh resheniya.* 1. pp. 426–428.

Antsyperov, V.V. & Ivanov, O.I. (2013) O roli dvigatel'noy asimmetrii v pryzhkakh v vodu. *Sov- remennye problemy nauki i obrazovaniya.* 6. pp. 1–5.

Apoyko, R.N. (2015) Analiz rezul'tatov vystupleniya vedushchikh peterburgskikh bortsov na chempionate Rossii 2015 goda po greko-rimskoy bor'be. *Uchenye zapiski universiteta imeni P.F. Lesgafta.* 124. pp. 15–20.

Ayrapet'yants, L.R. & Isroilov, Sh.Kh. (2015) Prioritetnost' simmetrichnogo razvitiya pravo- i levostoronnikh dvigatel'nykh funktsiy v sporte. *Nauka i sport: sovremennye tendentsii*. 3. pp. 18–23.

Bailey, C.A., Sato, K., Burnett, A. & Stone, M.H. (2015) Kinetic asymmetry and center of mass displacement during jumps. 33rd International Conference on Biomechanics in Sports. France. pp. 776–779.

Bazyler, C. et al. (2014) The effects of strength training on isometric force production symmetry in recreationally trained males. Journal of Trainology. 3. pp. 6–10.

Berdichevskaya, E.M. et al. (2007) Functional asymmetries at maintenance of effective activity in sports. Asimmetriya – *Journal of Asymmetry*. 1. pp. 62–64..

Berdichevskaya, E.M. & Gronskaya, A.S. (2009) Funktsional'nye asimmetrii i sport. In: Fokin, V.F. et al. (eds) Rukovodstvo po funktsional'noy mezhpolusharnoy asimmetrii. Moscow: Nauchnyy mir.

Blinov, V.A. & Semenyukov, A.A. (2013) Trenirovka yunykh futbolistov s uchetom funktsional'noy mezhpolusharnoy asimmetrii. *Voprosy funktsional'noy podgotovki v sporte vysshikh dostizheniy*. 1. pp. 238–245.

Bobina, O.N. (2007) Eksperimental'noe obosnovanie metodicheskikh priemov v obuchenii dvigatel'nym deystviyam s uchetom motornykh asimmetriy. *Vestnik TGPU – TSPU Bulletin.* 5 (68). pp. 28–30.

Bragina, N.N. & Dobrokhotova, T.A. (1981) Funktsional'nye asimmetrii. 2nd ed. Moscow: Meditsina.

Broca, P.P. (1861a) Perte de la parole, ramollissement chronique et desstruction partielle du lob antérieur gauche de cerveau [Loss of speech, chronic softening and partial destruction of left anterior brain lob]. *Bulletins de la Société d'Anthropologie.* 62. pp. 235–238.

Broca, P.P. (1861b) Remarques sur le siége de la faculté du langage articulé, suivies d'une observation d'aphemie (Perte de la Parole) [Remarks on the meeting of the faculty of articulate language, followed by an observation of aphemy (Loss of the Word)]. *Bulletins et mémoires de la Société Anatomique de Paris.* 36. pp. 330–357.

Bryukhanov, D.A. & Kornilov, Yu.P. (2014) Sovershenstvovanie dvigatel'nykh deystviy grebtsov s uchetom asimmetrii spetsial'nykh silovykh kachestv. *Sochi Journal of Economy*. 1 (29). pp. 222–225.

Butinov, K.V. (2011) Sensornaya i motornaya asimmetriya u lits s razlichnoy stepen'yu fizicheskoy podgotovki. *Problemy i perspektivy razvitiya obrazovaniya v Rossii*. 12. pp. 263–267.

Chermit, K.D. (1992) Simmetriya – asimmetriya v sporte. Moscow: Fizkul'tura i sport.

Chermit, K.D. (2004) Garmonicheskaya para "simmetriya – asimmetriya" v organizme cheloveka kak fundamental'naya osnova adaptatsii. Abstract of Biology Candidate Dissertation. Krasnodar.

Chermit, K.D., Shakhanova, A.V. & Zabolotniy, A.G. (2014) O sushchnosti laterostressa (nauchnaya gipoteza). *Vestnik Adygeyskogo gosudarstvennogo universiteta*. 3 (142). pp. 72–79.

Chibis, V.O. (1997) Rol' funktsional'noy asimmetrii pri otsenke i prognozirovanii adaptivnykh rezervov organizma cheloveka. Abstract of Medicine Candidate Dissertation. Moscow.

Chikurov, A.I., Fedorov, V.I., Voinich, A.L. & Khudik, S.S. (2016) Directed asymmetric power action as effectivization factor in sprint coaching. *Journal of Physical Education and Sport.* 16 (4). pp. 1287–1292.

Chivil', A.A. & Stepanova, I.A. (2014) Korrektsiya asimmetrii razvitiya fizicheskikh sposobnostey v khudozhestvennoy gimnastike na etape uglublennoy podgotovki. *Uchenye zapiski universiteta imeni P.F. Lesgafta*. 7 (113). pp. 186–189.

Chivil', A.A. & Stepanova, I.A. (2014) Effektivnost' primeneniya sredstv i priemov korrektsii dvigatel'noy asimmetrii na etape uglublennoy podgotovki v khudozhestvennoy gimnastike. *Uchenye zapiski universiteta im. P.F. Lesgafta.* 3 (109). pp. 191–194.

Ezhova, N.M. & Strel'nikova, I.V. (2013) Sravnitel'nyy analiz metodik korrektsii asimmetrii usiliy, prikladyvaemykh na lopasti vesla, u kvalifitsirovannykh grebtsov. *Voprosy funktsional'noy podgotovki v sporte vysshikh dostizheniy.* 1. pp. 260–266.

Fetisova, S.L. et al. (2016) Formirovanie individual'nogo profilya asimmetrii sredstvami voleybola i ispol'zovanie ikh v professional'noy podgotovke voennosluzhashchikh. *Problemy sovremennogo pedagogicheskogo obrazovaniya.* 50–3. pp. 183–191.

Filin, V.P. (1964) Beg na korotkie distantsii. Moscow: Fizkul'tura i sport.

Fomina, E.V. (2006) Funktsional'naya asimmetriya mozga i adaptatsiya cheloveka k ekstremal'nym sportivnym nagruzkam. Abstract of Biology Candidate Dissertation. Tyumen.

Fritsch, G. & Hitzig, E. (1870) Ueber die elektrische Erregbarkeit des. Archiv für Anatomie, Physiologie und wissenschaftliche Medicin.

Gore, S. et al. (2014) A comparison of asymmetry in athletic groin pain patients and elite rugby union players using analysis of characterizing phases. *International Conference of Biomechanics in Sports*. pp. 237–240.

Gramatikopolo, S.N. (2011) Vliyanie funktsional'noy asimmetrii na kachestvo grebkov u yunykh plovtsov 8–10 let. *Vestnik sportivnoy nauki.* 2. pp. 28–30.

Gronskaya, A.S., Davanova, A.V., Maluka, M.V. & Bugaets, Ya.E. (2014) Vliyanie motornoy asimmetrii na professional'no-tekhnicheskie kha- rakteristiki zhenshchin-beguniy na 400 metrov s bar'erami. *Voprosy funktsional'noy podgotovki v sporte vysshikh dostizheniy*. 2014. pp. 72–77.

Gutnik, B. & Kobrin, V.I. (2007) Manual'naya motornaya asimmetriya: tsentral'noe ili perifericheskoe proiskhozhdenie. *Asimmetriya.* 1 (1). pp. 69–70.

Humphrey, G.M. (1861) The human foot and the human hand. Cambridge, England: Macmillan & Co., Ltd.

Ignat'eva, L.E. & Maydokina, L.G. (2016) Diagnostika mezhpolusharnoy asimmetrii u sportsmenov-igrovikov. *Sovremennye problemy nauki i obrazovaniya*. 4. pp. 66.

Il'in, E.P. (2001) Differentsial'naya psikhofiziologiya. St. Petersburg: Piter.

Khachaturova, I.E. (2012) Funktsional'nye asimmetrii u sportsmenov, spetsializiruyushchikhsya v pulevoy strel'be. Abstract of Biology Candidate Dissertation. Krasnodar.

Khachaturova, I.E. (2015) Kharakter individual'nogo profilya asimmetrii v protsesse godichnogo tsikla podgotovki sportsmenov-strelkov. Resursy konkurentosposobnosti sportsmenov. Krasnodar: KubGUFK.

Kletsov. K.G., Povalyaeva, E.I. & Avraleva, E.I. (2015) Sovershenstvovanie kachestva vypolneniya broskov predmetov na etape spetsializirovan- noy podgotovki v khudozhestvennoy gimnastike. *Fizkul'turnoe obrazovanie Sibiri*. 2015. 2. pp. 26–29.

Knapik, J.J. et al. (1991) Preseason strength and flexibility imbalances associated with athletic injuries in female collegiate athletes. *Am J Sports Med*. 19 (1). pp. 76–81.

Komai, T. & Fukuoka, G. (1934) A study on the frequency of left-handedness and left-footedness among Japanese school children. *Human Biology.* 6. pp. 33–42.

Korobeynikov, G.V. et al. (2014) Funktsional'naya mezhpolusharnaya asimmetriya mozga i kognitivnye funktsii u elitnykh bortsov. *Voprosy funktsional'noy podgotovki v sporte vysshikh dostizheniy*. 2. pp. 53–63.

Kostyuchenko, V.F. et al. (2008) Obobshchenie prakticheskogo opyta po "sglazhivaniyu" lateral'noy asimmetrii v podgotovke tyazheloatletov. *Uchenye zapiski universiteta imeni P.F. Lesgafta*. 1 (35). pp. 52–56.

Kostyuchenko, V.F., Stepanov, V.S. & Alekseev, A.A. (2008) Asimmetriya biomekhanicheskoy struktury dvizheniy tyazheloatletov. *Uchenye zapiski universiteta imeni P.F. Lesgafta*. 2 (36). pp. 59–64.

Kovalchuk, G.I. (2015) Model of selection of short distances runners in the sports training early stages. *Omskiy nauchnyy vestnik – Omsk Scientific Bulletin.* 2. pp. 186–189.

Kozlov, I.M., Samsonova, A.V. & Stepanov, V.S. (2005) Dikhotomiya (simmetriya – asimmetriya) fizicheskogo razvitiya sportsmenov. *Teoriya i praktika fizicheskoy kul'tury*. 4. pp. 24–26.

Kudryashova, Yu.A., Berdichevskaya, E.M. & Moshoy, A.A. (2014) Funktsional'nyy profil' asimmetrii u kvalifitsirovannykh sportsmenov, spet- sializiruyushchikhsya v legkoy atletike (pryzhki v dlinu). *Vestnik Ural'skoy meditsinskoy akademicheskoy nauki*. 3. pp. 186–188.

Lavren't'eva, D.A. (2015) Nachal'noe obuchenie plavaniyu detey mladshego shkol'nogo vozrasta s uchetom motornykh asimmetriy. Abstract of Pedagogy Candidate Dissertation. Malakhovka.

Lavren't'eva, D.A. (2016) Osobennosti rezul'tatov sorevnovatel'noy deyatel'nosti plovtsov 10–12 let s raznymi tipami profiley motornoy asim- metrii. *Vestnik Adygeyskogo gosudarstvennogo universiteta*. 2 (178). pp. 125–132.

Litvinenko, Yu.V. et al. (2015) Statodinamicheskaya ustoychivost' tela gimnastov vysokoy kvalifikatsii. *Pedagogika, psikhologiya i Mediko-biologicheskie problemy fizicheskogo vospitaniya i sporta*. 1. pp. 46–51.

Masyuk, A.I. (1939) Korregirovanie funktsional'noy asimmetrii fizicheskimi uprazhneniyami kak metod povysheniya sportivno-tekhnicheskikh rezul'tatov. Kharkov.

Moskvin, V.A. & Moskvina, N.V. (2015) Individual'nye razlichiya funktsional'noy asimmetrii v sporte. *Nauka v Olimpiyskom sporte.* 2. pp. 58–62.

Moskvina, N.V. & Moskvin, V.A. (2010) Levorukost' v sporte vysshikh dostizheniy. *Sportivnyy psikholog*. 2 (20). pp. 25–29.

Nabieva, K.N. & Mendzheritskiy, A.M. (2015) Asimmetriya miograficheskikh pokazateley ruk u mal'chikov s raznym lateral'nym profilem. *Nauchnye issledovaniya: ot teorii k praktike.* Vol. 5 (6). Proceedings of the VI international conference. Cheboksary. 31 December 2015. Cheboksary: Interaktiv plyus. pp. 16–19.

Petrova, N.A. (2006) Osobennosti morfofunktsional'nogo razvitiya i formirovanie funktsional'noy asimmetrii detey 2–6 let. Abstract of Biology Candidate Dissertation. Kazan.

Petrovskiy, V.V. (1978) Beg na korotkie distantsii. Moscow: Fizkul'tura i sport.

Plotnikov, S.G. & Mar'yanovskiy, A.A. (2007) Funktsional'noe sostoyanie elitnykh sportsmenov-lyzhnikov s uchetom dvigatel'noy asimmetrii. *Teoriya i praktika fizicheskoy kul'tury*. 1. pp. 42–45.

Poluektov, E.S. (2013) Vliyanie fizicheskikh nagruzok na sostoyanie oporno-dvigatel'nogo apparata begunov na srednie distantsii. *Uchenye zapiski universiteta imeni P.F. Lesgafta*. 12 (106). pp. 120–123.

Potseluev, A.A. (1960) Asimmetriya dvizheniy. *Teoriya i praktika fizicheskoy kul'tury.* 7. pp. 496–498.

Pozharskaya, E.N. (1996) Psikhofiziologicheskie kharakteristiki lits s raznym profilem funktsional'noy mezhpolusharnoy asimmetrii mozga. Abstract of Biology Candidate Dissertation. Rostov-on-Don.

Remeeva, A.F. K voprosu o nedopustimosti pereuchivaniya levshey [On the inadmissibility of re-training left-handers]. [Online] Available from: http://www.levshei.net/10.html.

Rynkiewicz, M., Rynkiewicz, T. & Starosta, W. (2013) Asymmetry of Spinal Segments Mobility in Canoeists and its Relationship with Racing Speed. *Human Kinetics*. 36. pp. 37–43.

Rynkiewicz, M., Rynkiewicz, T., Zurek, P. & Ziemann, E. (2013) Asymmetry of muscle mass distribution in tennis players. *Trends of Sports Science*. 1 (20). pp. 47–53.

Sedochenko, S.V. (2015) Pedagogicheskaya korrektsiya asimmetrichnoy nagruzki u yunykh sportsmenov na osnove primeneniya sredstv srochnoy informatsii (na primere fekhtovaniya i tennisa). Abstract of Pedagogy Candidate Dissertation. Moscow.

Semenyukov, A.A. (2009) Ratsionalizatsiya metodiki trenirovki yunykh futbolistov s uchetom razlichnykh proyavleniy motornoy asimmetrii nog . *Uchenye zapiski universiteta imeni P.F. Lesgafta*. 11. pp. 86–89.

Shestakov, M.P. et al. (2010) Issledovanie koordinatsionnoy struktury sportsmenov v vidakh sporta s asimmetrichnym vypolneniem dvizheniya. *Izvestiya YuFU. Tekhnicheskie nauki*. 9 (110). pp. 174–178.

Shevtsov, A.V. (2012) Funktsional'noe sostoyanie vistseral'nykh sistem organizma sportsmenov pri nemedikamentoznom sposobe korrektsii myshechno-tonicheskoy asimmetrii paravertebral'noy zony. Abstract of Biology Candidate Dissertation. Chelyabinsk.

Sologub, E.B. & Taymazov, V.A. (2000) Sportivnaya genetika. Moscow: Terra Sport.

Stier, E. (1911) Untersuchungen über Linkshändigkeit und die funtionellen Differenzen der Hirnhälften [Studies on left-handedness and the functional differences of the cerebral hemispheres]. Fischer. Jena.

Stöggl, T., Hébert-Losier, K. & Holmberg, H.C. (2013) Do Anthropometrics, Biomechanics, and Laterality Explain V1 Side Preference in Skiers? *Med. Sci. Sports Exerc.* 45 (8). pp. 1567–1576.

Taymazov, V.A. & Bakulev, S.E. (2006) Znachenie funktsional'noy asimmetrii kak geneticheskogo markera sportivnykh sposobnostey. *Uchenye zapiski universiteta imeni P.F. Lesgafta*. 22. pp. 74–82.

Trishin, A.S., Trishin, E.S., Berdichevskaya, E.M. & Katrich, L.V. (2015) Features of postural factors during exposure to lateralized controls in athletes skilled at situational sports. *Asimmetriya.* 1 (9). pp. 4–11.

Van Biervliet, J.J. (1897) L'asymétrie sensorielle [Sensory asymmetry]. Extrait des Bulletins de l'Académie royale de Belgique. 3:XXXIV:8. 43 p.

Vasil'ev, D.A., Strel'nikova, I.V. & Laktionova, T.I. (2014) Koordinatsionnye sposobnosti yunykh khokkeistov s raznym tipom funktsional'noy asimmetrii. *Voprosy funktsional'noy podgotovki v sporte vysshikh dostizheniy*. 2. pp. 96–98.

Zagrevskaya, A.I. (2016) Kontseptsiya fizkul'turno-sportivnogo obrazovaniya studentov na osnove kineziologicheskogo podkhoda. *Kul'tura fizicheskaya i zdorov'e.* 1 (56). pp. 30–32.

Zamchiy, T.P., Lozhkina-Gametskaya, N.I. & Spataeva, M.Kh. (2014) Asimmetriya v podderzhanii vertikal'noy pozy u sportsmenov. *Sovremennye problemy nauki i obrazovaniya*. 3. pp. 610.