Original Article

Young cyclists' vestibular stability and balance development at an initial training stage

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Abstract:

Research aim: development and testing of a comprehensive method effectiveness for improving vestibular stability and balance function in young athletes at an initial training stage in cycling - mountain bike.

Material and methods. The pedagogical experiment was conducted on the basis of the specialized Olympic reserve school (cycling) in Kopeisk (Russia). Boys aged 11-12, athletes training at the initial training group in cycling-mountain bike took part in our experiment. The proposed experimental method for improving vestibular stability is based on the principle of integrated use of a set of training tools and organizational and pedagogical conditions for their implementation. The developed physical exercises performed on the Bosu Balance Pod (bosu) hemisphere, a roller bike stand and a specialized training bike track were used. To determine the state of athletes' static balance, functional tests of Romberg-2 were performed, N. A. Bondarevsky's control exercises with open and closed eyes (sec), for dynamic balance - turns on the gymnastic bench for 20 seconds. The vestibular analyzer state was assessed by A. I. Yarotzky's test (sec). The athletes' physical fitness was determined using motor tests. *Research results.* Developed and tested integrative technology for developing young athletes' vestibular stability and coordination abilities at an initial training stage in cycling-mountain bike, had a more pronounced impact on these qualities development. Significantly greater increase in athletes' physical and technical fitness in the experimental group than in the control one was found. *Conclusions.* The proposed method of improving vestibular stability, balance function and coordination abilities can be recommended for use at an initial training stage in young cyclists' specializing in mountain biking training process.

Key Words: mountain bike, training process, vestibular stability, coordination

Introduction

Cycling as a cyclic type of sports activity is characterized by monostructural locomotions (Moss et al., 2019) with maximum, submaximal and high aerobic capacity of physical loadings (Hebisz, 2019). Rotational movements, frequent changes in the direction vector and locomotions speed, as well as the static position of the body during the elements execution, their connections and seat height have a large specific weight (Dedieu, 2020). These features impose not only high aerobic requirements on the student's body, but also the ability to navigate in space, hold the seat in a bicycle saddle in a semi-bent position at high speeds with static loadings on the muscles of the upper limbs and back (Camara et al., 2012; Emanuele et al., 2012).

A well-developed bicyclists' vestibular analyzer can simultaneously improve coordination abilities of the body, spatial and temporal orientation, the ability to coordinate movements and balance, and the response speed. All this contributes to the successful mastering motor actions' complex elements and ligaments, increases technical skill and high sports results achievement (Ljubojević, Bojanić, et al., 2016; Nazarenko &, Chinkin, 2015).

The vestibular apparatus functioning is closely related to the work of the visual, proprioceptive, interoceptive and tactile systems of the body (Kozlovskaya, 2017), it ensures the body balance, coordination and motor actions analysis (Nazarenko & Chinkin, 2015). The work of leading experts in various sports has experimentally confirmed the opinion that vestibular training should begin at an early age especially in children focused on complex-coordination sports, such as hockey (Dayanova et al., 2020), handball (Evseev et al., 2017; Bykova, 2017), figure skating (Groshev et al., 2018), dance

(Shaposhnikova et al., 2017), archery (Antonov, 2017), and cycling (Gerth et al., 2020; Miller et al., 2019). The scientists' research works show the importance of improving central nervous system coordination and interaction with all analyzers in order to increase the vestibular stability and balance function of the body (Badalov et al., 2015; Isroilov & Khusainova, 2017).

Scientific and methodological literature analysis has shown that there is no consensus among specialists about the types and methods of training this body function (Khudyakov et al., 2014). Some researchers believe that the vestibular stability of the body is largely due to inherited factors and to a lesser extent develops during training. Most authors believe that certain features of the vestibular analyzer can be improved by using specialized loads (Ziambetov, 2019). Therefore, it is important to improve the vestibular apparatus function at young athletes' initial training stage to achieve the highest sports mastery.

In the existing programs for children's and youth sports schools in Russia on cycling-mountain bike¹ in «athletes' special physical training» section, the vestibular stability development is not given due attention. In addition, the methods of implementation (selection of tools, methods, lessons organization) of this training section are not specified. There are practically no scientifically based tools and methods for developing vestibular stability for young cyclists aged 11-12, specializing in mountain biking, it reduces the training process effectiveness.

Thus, there is no single approach to the selection of tools, methods, organization and conducting training sessions aimed at young athletes' aged 11-12, specializing in mountain bike cycling, vestibular stability and balance function development.

Material & methods

Research aim: development and testing of a comprehensive method effectiveness for improving vestibular stability and balance function in young athletes at an initial training stage in cycling - mountain bike.

Research materials and methods. *Research participants and organisation.* The pedagogical experiment was conducted in 2018-2019 on the basis of the specialized Olympic reserve school (cycling) in Kopeisk (Russia). Boys aged 11-12, athletes training at the initial training group (second studying year) in cycling-mountain bike took part in our experiment. The cyclists were divided into 2 groups: control (CG) and experimental (EG), 12 persons in each. Training lessons were held 3 times a week for 2 hours during 52 weeks. The annual load was 312 hours.

The pedagogical experiment peculiarities. The proposed experimental method for athletes' aged 11-12 improving vestibular stability, balance function and coordination abilities is based on the principle of a complex of training tools and organizational and pedagogical conditions for their implementation integrated use. We used specially designed physical exercises performed on the Bosu Balance Pod (bosu) hemisphere, a Exercises at the bike station were conducted 2 times a week for 50-60 minutes: 10 minutes-a series of exercises was performed in the fixed position, without pedalling; 20 minutes – in the fixed position with pedalling; 10 minutes – in the fixed position without pedalling; 20 minutes-in the loose position with pedalling. The exercises were performed with visual and without visual control of the participants; video recording of the route and musical accompaniment were used. The rest break between each complex was 3-4 minutes and a specialized 100m x 4 training track.

Table 1 shows means of vestibular stability, balance function and coordination abilities training in a week-long micro-cycle of mountain bikers' aged 11-12 training.

Table 1
Means of cyclists-mountain bikers' vestibular stability, balance function and coordination abilities training

Week days	Vestibular stability training means		
	Exercises set on the bosu hemisphere	Exercises on a roller bike stand	Tasks on a specialized training track.
Monday	+	–	+
Wednesday	–	+	+
Friday	–	+	+

In order to improve body management skills and develop coordination abilities, special complexes of balancing exercises were developed, performed on the Bosu Balance Pod (bosu) hemisphere, with and without visual control. Exercises on the bosu hemisphere are aimed at developing static and dynamic balance. All applied exercises are associated with the loading on the visual and kinesthetic analyzer, require attention, performance self-control, the need for constant correction of their performance the accuracy.

Exercises complexes on the bosu hemisphere were used in the preparatory part of the lesson and made up about 15% (13-15 minutes) of the total duration of training. Each set included 12-15 physical exercises on

¹ Cycling: exemplary program of sports training for children's and youth sports schools, specialized children's and youth sports schools of the Olympic reserve and schools of higher sports skill. Moscow: Sovetsky Sport. 2008. 160 p.

bosu and was performed by cyclists once a week (on Monday). A roller bike develops the ability to hone steering skills and maintain balance. In our work, it was used in training mountain bike cyclists in the following positions: fixed, without pedalling; fixed with pedalling; loose with pedalling. Exercises at the roller bike stand were conducted 2 times a week for 50-60 minutes. A specialized training track for mountain bikers consisted of four sections 100 m long that ran through a forest belt. Special exercises for managing the body and developing the ability to balance were performed on the bicycle track with obstacles. Tasks on the training track were applied in the main or final part of the training session and accounted for 20-25% of the training total duration. Once a week (Monday), conditioning exercises or sports games were used in the final part of the training.

The control group was engaged in the training program developed on the basis of the Federal standard of sports training in the sport «Cycling-mountain bike» (approved by the order of the Ministry of Sports of Russia No. 401 of 18.06.2013) and designed for children, aged 10 and older. At the stage of initial preparation during the second training year in the training process structure, conditioning physical training was 40% in terms of time, special physical training – 32%, technical - 25%, tactical - 2.5% and competitive activity - 0.5%. Coordination exercises in the program are not singled out separately and are mastered as they pass conditioning physical and special physical training. To determine the athletes' static balance state, we used functional tests of Romberg-2 (sec) (Khasnis, Gokula, 2003), N. A. Bondarevsky's control exercises with open and closed eyes (sec) (Bondarevsky, 1966) and dynamic balance - turns on a gymnastic bench for 20 seconds. (number of times) (Starosta, Hirtz, 1989). The vestibular analyzer condition was evaluated by A. I. Yarotzky's test (Egorova, 2013).

The athletes' state physical fitness was determined using motor tests presented in the Federal standard of sports training for cycling-mountain bike sport, some of which are included in European and American tests^{2,3}. A battery of tests was used: running 30 m on the move (sec); standing long jump (cm); a stuffed ball 3.0 kg throwing in a sitting position from behind the head, (m); running 800 m, (sec); individual time race-5 km, (sec); pull-up on the crossbar, (number of times); lifting the body, lying on the back, (number of times); shuttle run 3x10 m, (sec). The technical readiness assessment of EG and CG boys was carried out on a five-point scale based on the results of 10 control exercises (landing technique, pedalling; braking and stopping technique, even movement over the distance; technique of selecting and switching gear ratios: start and start acceleration technique; technique of passing turns, overcoming climbs and descents, overcoming obstacles; straight-line movement technique). Statistical description of the sample was performed by calculating the median (Me) and interquartile range in the form of 25 and 75 percentiles (Q_{25} - Q_{75}). The hypothesis about the statistical significance of the studied indicators values was tested using the Wilcoxon-Mann-Whitney test. The differences were considered statistically significant at the $p < 0.05$ level. According to the value of one or another indicator, the observed athletes' sample was divided into 5 sigma classes: $M \pm 0.67 \sigma$ – the «average» value of the indicator for the sample. If the value of the indicator was in the range from $M \pm 0.67 \sigma$ to $M \pm 1.34 \sigma$, the attribute was evaluated as «above average» or «below average». If the value of the indicator was outside $M \pm 1.34 \sigma$, the gradation was as «high» or «low». We used Statistica 6.0 application software package in our research.

The work performed does not infringe on the schoolchildren's rights or endanger their well-being in accordance with the ethical standards of the Human Rights Committee of the Helsinki Declaration of 2008⁴. The parents' consent to the children's examination was obtained.

Results

At the pedagogical experiment beginning (September 2018), there were no significant differences between the vestibular samples values in athletes of the experimental and control groups ($p < 0.05$). After the experiment was completed (June 2019), all values of vestibular stability and balance function indicators in the experimental group were significantly higher (Table.2), than in the control one ($p < 0.05$).

Table 2
Indicator values of vestibular stability and balance function in EG and CG athletes after the experiment (Me; Q_{25} - Q_{75})

Functional tests, control exercises	EG (n=12)	CG (n=12)	P
Romberg-2 test (sec)	84,8	52,2	<0,05
A. I. Yarotzky's test (sec)	49,8	33,3	<0,05
N. A. Bondarevsky's test with open eyes (sec)	70,2	54,0	<0,05
N. A. Bondarevsky's test with closed eyes (sec)	41,8	30,1	<0,05
Turns on a gymnastic bench for 20 seconds. (number of times)	8,0	6,0	<0,05

² PCFSN. The president's challenge: Physical fitness test. 2011. [July 14, 2011]. Available from: <https://www.presidentschallenge.org/challenge/physical/index.shtml> (дата обращения: 28.02.2019).

³ Council of Europe. Testing physical fitness: Eurofit experimental battery-provisional handbook. 1983. [June 28, 2011]. <http://www.bitworks-engineering.co.uk/linked/eurofitpercentage20provisionalpercentage20handbook%20leger%20beep%20test%201983.pdf>.

⁴ WMA Declaration of Helsinki - Ethical Principles for Medical Research Involving Human Subjects.

In motor tests at the beginning of the experiment, there are no significant differences in the values of indicators in athletes EG and CG ($p > 0.05$).

At the end of the experiment, there were significant changes in the motor test values indicators in EG and CG. However, EG athletes have higher values of indicators in motor tests than CG boys.

The assessment of the EG and CG athletes' technical readiness before the experiment did not establish significant differences. At the same time, the boys in both groups were mostly of average and below average technical training levels. Compared with CG boys, at the end of the experiment, the level of technical exercise performance evaluation by EG cyclists increased in individual tests by 20.5-29.5%. The number of EG cyclists with a «high» and «above average» technical exercise rating increased to 41.7 and 41.7%, respectively. In CG, athletes with a high level were not found, the level of «above average» was 16.6% of boys, the rest had a low technical training level.

Dicussion

Vestibular stability is one of a person's important physical qualities, which is used in 98%, and movements' coordination - in 78% of known professions (Bishaeva, 2017). These qualities are necessary for children with central nervous system (Porotikov et al., 2018) and the hearing organ disorders (Selitrenikovas et al., 2019). Most types of physical culture and sports activities require vestibular stability and movements' coordination (Wilczyński, 2018; Tzybikov et al., 2019). The ability to maintain balance when performing motor actions is an integral indicator not only of motor formation level in people with different training levels, but also of the visual analyzer, proprioceptors and tactile sensitivity state, which, in turn, depend on the ability of the body to maintain a stable position of the body in space.

Success in cycling is largely determined by an athlete's vestibular stability level development, body balance function and movements' coordination. Our studies of the athletes' vestibular stability confirm other authors' data that the primary school age, to which the observed boys-athletes are referred, is a sensitive period of the child's vestibular stability and coordination abilities development (Willwéber & Čillik, 2017). Knowledge of the sensitive period features in a particular motor quality development makes it possible to conduct effectively not only sports selection among children, but also to rationally build their training process. Specially developed physical exercises use performed on the Bosu Balance Pod (bosu) hemisphere, a roller bike trainer and a specialized training bike track in the training process allowed us to significantly improve the young athletes' vestibular stability indicators and balance functions, which is consistent with the results of other authors' research who conducting observations in other sports (Bykova, 2017, Groshev et al., 2018, Shaposhnikova et al., 2017, Antonov, 2017).

According to our data, the increase in physical fitness indicators in EG was significantly higher than in

CG (Fig.).

Figure . Increase in young cyclists' (EG and CG) physical fitness indicators after a pedagogical experiment (%)

Note: - 1 - running 30 m on the move (sec); 2 - standing long jump (cm); 3 - a stuffed ball 3.0 kg throwing in a sitting position from behind the head, (m); 4 - running 800 m, (sec); 5 - individual time race-5 km, (sec); 6 - pull-up on the crossbar, (number of times); 7 - lifting the body, lying on the back, (number of times); 8 - shuttle run 3x10 m, (sec).

We have reliably established a significant increase in physical and technical fitness indicators in athletes from the experimental group, in comparison with the control one. The level of competitive success in many sports is closely related to the level of vestibular analyzer stability (Paschenko et al., 2017; Vardar, 2007). At the same time, reduced physical fitness leads to poor movements' coordination and impaired vestibular stability (Kotov-Smolenskiy et al., 2020). Researchers from Volgograd found a decrease in vestibular stability in individuals with low weekly motor activity (Doletzky et al., 2019), which confirms the close relationship of motor, coordination qualities and vestibular stability of the human body.

The use of our proposed integrative pedagogical technology for the vestibular stability and coordination abilities development allowed us to improve the characteristics of the latter in EG athletes. This can be evidenced by a significant improvement in the indicators value in the basic motor test «Shuttle run 3x10 m». As can be seen from Figure, the growth rate of the indicator value in EG was more than 2 times higher than in CG athletes.

The results of our research and testing the young athletes' vestibular stability showed an acceptable possibility of using conventional tests (Romberg, Bondarevsky, Yarotzky) to assess the vestibular apparatus and coordination abilities state using a basic test (Shuttle running). We believe that at the initial stage of sports specialization, it is acceptable to use generally accepted basic methods for assessing vestibular stability, and at the stage of higher sports skill, it is possible to use specific tests.

Conclusions

The integrative pedagogical technology of the program for young athletes' vestibular stability and coordination abilities development at the stage of initial training in cycling-mountain bike has been developed. The proposed experimental method is based on the principle of a comprehensive approach to the selection of tools and exercises, which consists in special complexes of physical exercises use, performed on the Bosu Balance Pod (bosu) hemisphere, a roller bike stand and a specialized training track in young athletes' training process.

The experimental method showed a more pronounced effect on young athletes' vestibular stability, balance function and coordination abilities the development, as well as their physical and technical fitness. EG athletes have significantly better values of indicators in the Romberg's-2, Yarotsky's, Bondarevsky's samples, turns on the gymnastic bench for 20 seconds than CG ones. At the end of the experiment, there was an improvement in the physical fitness indicators of CG and EG boys. However, the latter have higher values of indicators in all motor tests than the CG cyclists. The technical training level in EG athletes' individual exercises increased by 20.5-29.5%, compared to the results of CG boys.

The proposed method of improving vestibular stability, balance function and coordination abilities can be recommended for use at the initial training stage in young cyclists' specializing in mountain biking training process. The received data expand theoretical knowledge in the field of physical culture and sports related to cyclists' training process.

Conflicts of interest.

No potential conflict of interest relevant to this article was reported.

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