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The use of fitness equipment in the training of badminton players with hearing impairments: a review of research

Vladyslav Sterin,

PhD Student, Faculty of Physical Education and Sports, H.S. Skovoroda Kharkiv National Pedagogical University, Kharkiv, Ukraine

https://orcid.org/0009-0003-6897-2885

Iryna Podmaryova,

Senior lecturer of the Department of healthy life style and life safety; Semen Kuznets Kharkiv National University of Economics, Kharkiv, Ukraine

https://orcid.org/0000-0002-9339-6504

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Abstract: *The purpose of the work is to conduct a theoretical analysis of modern scientific sources on the use of fitness equipment in the training of badminton players with hearing impairments, to summarize its impact on the development of physical qualities, coordination abilities, and sensorimotor functions, and to determine the most effective directions for its implementation in the training process.* ***Research methods.*** *The study is based on the analysis and synthesis of scientific literature. The selection of scientific works was carried out using international scientometric databases Scopus, Web of Science, and the Google Scholar search engine. The literature search was performed using keywords in Ukrainian and English: "badminton", "fitness equipment", "hearing impairment", "deaf athletes". The initial search identified 576*

scientific publications corresponding to the general topic of the study. After screening according to relevance criteria, 19 publications were selected for in-depth analysis. Among them, 5 studies contained the most significant information on the use of fitness equipment in the training of badminton players with hearing impairments. ***Results.*** *The analysis of the selected studies showed that the use of modern fitness technologies, specialized coordination exercises, visual and tactile signal-based drills, reaction light systems, shadow training, body stabilization exercises, and vestibular system development significantly improves the physical fitness and technical preparedness of athletes with hearing impairments. The application of adapted training methods helps compensate for limitations of the auditory analyzer and contributes to the improvement of spatial orientation, postural control, and accuracy of motor actions.* ***Conclusions.*** *Modern fitness equipment is not only a means of physical conditioning but also an effective tool for the sensory adaptation of athletes with hearing impairments. Its targeted use in the training structure of badminton players enhances motor fitness, optimizes technical and tactical performance, and supports the development of stable compensatory mechanisms of sensorimotor control.*

Keywords: *badminton, athletes with hearing impairments, fitness, fitness equipment, adaptive sports, research review.*

Використання засобів фітнесу у підготовці бадмінтоністів з порушеннями слуху: огляд досліджень

Стерін Владислав Михайлович,
аспірант факультету фізичного виховання і спорту Харківського національного педагогічного університету імені Г.С. Сковороди, Харків, Україна, https://orcid.org/0009-0003-6897-2885

ПЕДАГОГІЧНА АКАДЕМІЯ:
НАУКОВІ ЗАПИСКИ

Подмарьова Ірина Анатоліївна,
старший викладач ст. викладач кафедри здорового способу життя, технології і безпеки життєдіяльності ХНЕУ ім. С. Кузнеця, Харків, Україна, https://orcid.org/0000-0002-9339-6504

Анотація: ***Мета роботи*** *здійснити теоретичний аналіз сучасних наукових джерел щодо використання засобів фітнесу у підготовці бадмінтоністів з порушеннями слуху, узагальнити їх вплив на розвиток фізичних якостей, координаційних здібностей і сенсомоторних функцій та визначити найбільш ефективні напрями їх впровадження у тренувальний процес.* ***Методи дослідження:*** *аналіз і узагальнення наукової літератури, підбір наукових праць здійснювався з використанням міжнародних наукометричних баз даних Scopus, Web of Science, а також пошукової системи Google Scholar. Пошук літератури проводився за ключовими словами українською та англійською мовами: «badminton», «fitness equipment», «hearing impairment», «deaf athletes», «fitness training», «adaptive sport». Первинний пошук дозволив виявити 576 наукових публікацій, що відповідали загальній тематиці дослідження. Після відбору за критеріями релевантності було визначено 19 праць для поглибленого аналізу. Із них 5 наукових робіт містили найбільш суттєву інформацію щодо застосування засобів фітнес у підготовці бадмінтоністів із порушеннями слуху.* ***Результати.*** *Аналіз досліджень показав, що застосування сучасних фітнес-технологій, спеціалізованих координаційних вправ, вправ із візуальними та тактильними сигналами, reaction lights technology, shadow training, вправ на стабілізацію корпусу та розвиток вестибулярного апарату позитивно впливає на фізичні якості та технічну підготовленість спортсменів із вадами слуху. Використання адаптованих методів тренування дозволяє компенсувати обмеження слухового аналізатора та сприяє покращенню просторової орієнтації, постурального контролю й точності рухових дій.* ***Висновки****. Сучасні засоби фітнесу*

виступають не лише засобом фізичної підготовки, але й ефективним інструментом сенсорної адаптації спортсменів із порушеннями слуху, їх цілеспрямоване застосування у структурі підготовки бадмінтоністів забезпечує підвищення рівня рухової підготовленості, оптимізацію техніко-тактичних дій та формування стійких компенсаторних механізмів сенсомоторного контролю.

Ключові слова: *бадмінтон, спортсмени з порушеннями слуху, фітнес, засоби фітнесу, адаптивний спорт, огляд досліджень*

Statement of the problem. In the modern conditions of development of physical culture and sports, the problem of increasing the effectiveness of training of athletes with hearing impairments is of particular relevance, which is due to the need to ensure equal opportunities for their full participation in training and competitive activities. Badminton as a dynamic sport places high demands on the level of coordination abilities, reaction speed, spatial orientation and accuracy of movements, which is complicated by the limitation of auditory perception in this category of athletes [4, 17].

The modern system of sports training actively uses various fitness equipment and innovative methods aimed at developing the physical qualities and functional capabilities of athletes[20,21]. These include exercises with elastic bands, balancing platforms, functional training, coordination complexes and other means that increase the effectiveness of the training process. The authors emphasize that functional fitness is an effective means of training athletes of various specializations, as it combines the development of physical qualities with the improvement of coordination mechanisms. The effectiveness of such training is ensured by the use of exercises with one's own body weight, unstable surfaces, coordination platforms and multi-joint movements. The main attention is paid to the development of dynamic balance, spatial orientation, stabilization of the body and accuracy of motor actions. The results obtained can be

used in the development of training programs in sports where reaction speed, balance and accuracy of movements are important, in particular in badminton [19].

An analysis of the scientific and methodological literature indicates an insufficient number of studies that comprehensively consider the use of fitness technologies in the training of badminton players with hearing impairments. The problem of adapting traditional training aids to the peculiarities of sensory perception of such athletes, where visual, spatial and kinesthetic landmarks play a leading role, remains particularly relevant [18].

The insufficient scientific validity and systematization of approaches to the use of fitness aids in this context necessitates the generalization of existing research and the identification of promising directions for their implementation in the training process. In this regard, there is a need to review scientific works devoted to the use of fitness aids in the training of badminton players with hearing impairments, which will allow us to outline the current state of the problem and determine further ways to solve it.

Analysis of recent studies and publications.

Analysis of scientific sources shows that badminton is an effective means of developing physical qualities in people with hearing impairments. In particular, in the study of Srinivasan et. al. it was found that systematic badminton classes contribute to a significant improvement in the speed, coordination and technical indicators of athletes. The authors emphasize that a specially organized training process allows you to increase the level of physical fitness and contributes to a more effective mastering of the technical elements of the game [16].

The work of Ukrainian researchers has proven that the use of specially selected exercises, visual signals and adapted equipment contributes to the development of coordination abilities, balance and spatial orientation of badminton players with hearing impairments. The authors emphasize the feasibility of introducing elements of

fitness technologies, in particular exercises with balancing platforms, elastic bands and other means of functional training [13].

Studies devoted to coordination training also confirm the effectiveness of the use of game and combined methods. Thus, in the work of Sterin et. al. it was established that the use of sports games and specialized exercises in the training process contributes to a significant increase in the level of coordination abilities of athletes with hearing impairments. This is explained by the need for a quick response to a change in the game situation and high requirements for the accuracy of movements in badminton [18].

Particular attention in modern research is paid to the use of sensorimotor and multisensory technologies. In the work of Wang, X., Ren, P., Miao, X. et al. it was proven that training based on a combination of various sensory stimuli contributes to improving the ability to predict game situations and the speed of decision-making, which is of particular importance for athletes with hearing impairments, since it allows to compensate for the limitations of the auditory analyzer by developing visual and kinesthetic perception [20].

In this context, the results of the study by Hülsdünker T. et al. are important, confirming the role of auditory information in the formation of speed reactions. The absence or limitation of hearing in athletes requires the use of alternative channels of perception, which determines the relevance of the use of visual and tactile training tools[5].

General trends in the development of sports among people with hearing impairments are highlighted in a systematic review by Gawel E., Soto-Rey J., Zwierzchowska A., which emphasizes the need for individualization of the training process, the use of modern technologies and taking into account the psychophysiological characteristics of athletes. The authors emphasize that the implementation of innovative approaches contributes to increasing the performance and competitiveness of athletes [1].

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In addition, studies devoted to the development of visually oriented physical training programs have proven the effectiveness of using visual instructions, signals and movement models in the process of training people with hearing impairments. Such approaches provide a better understanding of the tasks and improve the quality of motor actions [7].

Additionally, it should be noted that in the field of parabadminton, the importance of adapting training programs in accordance with the individual capabilities of athletes is emphasized, as well as the use of various means of physical training, which allow for the effective development of both technical and tactical components of activity [15, 12].

The analysis of scientific sources shows that the problem of improving the training system for badminton players with hearing impairments is a relevant direction of modern theory and methodology of adaptive sports. Hearing impairment causes specific features of the formation of motor skills, coordination abilities, balance and reaction speed, which requires the implementation of specially adapted training approaches and fitness tools.

Highlighting previously unresolved parts of the overall problem. The analysis of scientific literature shows that the use of fitness technologies in combination with badminton equipment is a promising direction for increasing the effectiveness of training athletes with hearing impairments. The available studies are fragmentary in nature and mostly consider individual aspects of physical or technical and tactical training without their comprehensive combination in a single training system. There is a need for systematic generalization of scientific data and development of scientifically based approaches to the use of fitness technologies in the training of badminton players with hearing impairments, which determines the relevance of further research in this area.

Formulation of the article's purpose (task statement).

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The purpose of the work is to carry out a theoretical analysis of modern scientific sources on the use of fitness equipment and methods in the training of badminton players with hearing impairments, to summarize their impact on the development of physical qualities, coordination abilities and sensorimotor functions and to determine the most effective directions for their implementation in the training process.

Research objectives: to carry out a theoretical and methodological analysis of scientific sources on the problem of training badminton players with hearing impairments in the adaptive sports system; to determine the patterns of the influence of fitness equipment on the indicators of physical fitness and sensorimotor functions of athletes with hearing impairments; to substantiate the feasibility of using visually-oriented and sensorimotor approaches as means of compensating for a disturbed auditory analyzer; to systematize scientific and practical approaches to integrating fitness technologies into the structure of badminton players' training, taking into account their individual characteristics.

Research methods: analysis and generalization of scientific literature.

The organization of the study involved a systematic analysis of scientific sources devoted to the use of fitness equipment and methods in the training of badminton players with hearing impairments. The selection of scientific works was carried out using the international scientometric databases Scopus, Web of Science, as well as the Google Scholar search engine. The literature search was conducted using the following keywords in Ukrainian and English: “badminton”, “fitness equipment”, “hearing impairment”, “deaf athletes”, “fitness training”, “adaptive sport”. The initial search revealed 576 scientific publications that corresponded to the general topic of the study. At the next stage, selection criteria were applied to the titles and abstracts of the articles. The analysis included publications that met the following requirements: relevance to the topic of the study, the presence of empirical or survey data on the use of training equipment, studies published in peer-reviewed publications, and the availability of the full text. At the same time, works that were not related to sports training, duplicated

the results of other studies, or did not contain scientifically substantiated conclusions were excluded. As a result of the initial selection, 19 scientific works were selected for in-depth analysis. At the final stage, a detailed review of the full texts of the selected publications was carried out in order to systematize the data obtained, generalize modern approaches to the use of fitness equipment and methods, and determine their effectiveness in the training of badminton players with hearing impairments.

Presentation of the main research material. For a detailed theoretical analysis of the problem of using fitness equipment in the training process of badminton players with hearing impairments, 5 scientific papers were selected, which highlighted the features of using adaptive physical training equipment, technologies for developing balance, reaction speed, agility and coordination abilities of athletes of this nosology. The selected studies allowed us to generalize modern approaches to organizing the training process of badminton players with hearing impairments, as well as to determine the most effective means and methods of adaptive sports training (Table 1). Of the analyzed sources, 2 studies are devoted to the study of balance, reaction speed and anthropometric indicators of badminton players with hearing impairments [2; 6], 1 source reflects the influence of technical training in badminton on the development of biomotor and technical indicators of athletes [16], 1 study is devoted to the development of agility using reaction lights-based shadow training [10], and 1 article highlights the use of adaptive sports tools for the development of physical qualities and coordination abilities of badminton players with hearing impairments [13] (Table 1).

Table 1

List of analyzed publications on the research topic

Authors	Purpose of the study	Fitness equipment
Halil T., Ayla K. O., & Aziz, G. (2015) [2].	To analyze reaction time, balance indicators and some anthropometric characteristics in badminton players aged 12–15 with hearing impairments and healthy athletes.	exercises to develop static and dynamic balance; exercises to develop reaction speed; coordination exercises; exercises to develop sensorimotor control;vestibular neuromuscular training; core stabilization training
Kanber, C., & Boyalı, E. (2018) [6].	To determine the characteristics of balance in badminton players with hearing impairments and to	static balance exercises; dynamic balance exercises; coordination exercises; body

	investigate the impact of badminton practice on balance development by comparing athletes with hearing impairments and individuals who did not engage in sports	stabilization exercises; foam-floor exercises; postural control exercises
Srinivasan, Vijay, Vallimurug, Gnanavadivel (2022) [16].	To determine the impact of badminton technique training on individual biomotor and technical performance of college students with hearing impairments.	The main fitness and physical training tools used in the program included: speed exercises; abdominal strength exercises; flexibility exercises
Pratama, A. P., Sukamti, E. R., et al. (2024) [10].	to determine the impact of the shadow training method using reaction lights on the development of agility in badminton players with hearing impairments.	shadow training; footwork drills; agility exercises; reactive exercises for changing the direction of movement; training for the speed of response to a visual signal; coordination exercises; moving forward, backward, right and left on the court; exercises using reaction lights technology.
Sobko I., Sterin V., Sobko Y., Sterin M., Liubiieva V. (2025) [13].	To experimentally test the effectiveness of adaptive sports tools for developing the physical qualities of badminton players with hearing impairments.	exercises with visual signals using colored light; special bracelets with a sensory vibration beacon; coordination exercises with special equipment; exercises for the development of the vestibular apparatus; exercises to improve visual-motor coordination; exercises for the development of proprioceptive sensitivity; exercises with a skipping rope

The analysis of scientific sources showed that modern research in the field of training badminton players with hearing impairments is aimed at finding effective fitness tools and methods that can increase the level of physical and functional fitness of athletes. Considerable attention is paid to the use of exercises aimed at developing coordination abilities, balance, agility, reaction speed and sensorimotor control, which are important for successful competitive activity in badminton [10,18].

The analysis of research has shown that the use of modern fitness technologies, specialized coordination exercises, exercises with visual and tactile signals, reaction lights technology, shadow training, exercises for body stabilization and development of the vestibular apparatus has a positive effect on the physical qualities and technical fitness of athletes with hearing impairments. The use of adapted training methods

allows to compensate for the limitations of the auditory analyzer and helps to improve spatial orientation, postural control and accuracy of motor actions [9, 10].

Experts emphasize that the development of motor fitness of badminton players with hearing impairments requires the comprehensive use of specially selected tools aimed at improving balance, coordination and sensorimotor control [14]. A separate group of tools consists of exercises aimed at developing visual-motor reaction, static and dynamic balance, coordination abilities and special working capacity. These also include corrective tools aimed at optimizing body composition, as well as specialized vestibular-neuromuscular training, which improve the functional state of the athletes' musculoskeletal system.

In addition, modern adaptive tools are widely used in the training process, including signaling systems based on colored light, orientation markers (cones, cards) for organizing movements and performing strokes, as well as shadow exercises that involve imitating the opponent's movements without using a shuttlecock. Tactile stimuli (vibrating bracelets, physical contact, tactile marks, exercises with closed eyes) are also effective, which compensate for the lack of auditory control [10,13].

Coordination exercises with special equipment also play an important role, including balancing cushions, hemispheres, balls of different sizes and coordination ladders. Taken together, these tools are aimed at developing vestibular function, visual-motor coordination and proprioceptive sensitivity, which ensures an increase in the level of sensorimotor regulation of movements and general special preparedness of badminton players with hearing impairments [8, 11].

Generalization of the results of the analysis of scientific and methodological literature allows us to establish that the use of fitness equipment in the training of badminton players with hearing impairments has a pronounced multi-vector impact, which is manifested both in the development of physical qualities and in the improvement of sensorimotor coordination. First of all, the positive impact of the systematic use of fitness technologies on the indicators of general and special physical

fitness of athletes is natural. In particular, aerobic and interval training regimens contribute to an increase in the level of general endurance, which is critically important in badminton as a sport with high intensity of load and frequent changes in the pace of the game. Strength exercises using one's own weight, elastic supports and unstable surfaces contribute to the development of explosive strength, speed-strength qualities and muscle stabilization, which directly affects the effectiveness of impact actions and movement on the court. A separate regularity is the improvement of sensorimotor regulation of movements under the influence of visually-oriented and coordination exercises. In athletes with hearing impairments, partial compensation of the deficit of the auditory analyzer occurs due to an increase in the role of the visual system and proprioception. Performing exercises with visual signals (light indicators, coach's gestures, moving targets) helps to accelerate the choice reaction, reduce the latency time of the motor response and increase the accuracy of motor actions. An important regularity is also the effectiveness of integrating unstable supports and coordination platforms into the training process. Such means stimulate the development of static and dynamic balance, improve intermuscular coordination and contribute to the formation of rational motor patterns. In athletes with hearing impairments, this has additional importance, since it strengthens the compensatory mechanisms of controlling the body's position.

The justification of the feasibility of visually-oriented and sensorimotor approaches is based on the principle of multisensory compensation. In conditions of reduced or lost auditory control, the visual and kinesthetic analyzers begin to play a leading role in the regulation of movements. Accordingly, training programs built with an emphasis on visual signals, spatial orientation and tactile feedback provide more effective formation of motor skills and increase the stability of technical actions in competitive conditions.

Conclusions. Modern fitness equipment is not only a means of physical training, but also an effective tool for sensory adaptation of athletes with hearing impairments,

their targeted use in the structure of badminton players' training ensures an increase in the level of motor fitness, optimization of technical and tactical actions and the formation of stable compensatory mechanisms of sensorimotor control. It has been established that the use of exercises on unstable supports, coordination complexes, exercises with visual and tactile signals has a positive effect on the development of balance, reaction speed, agility, stabilization of the body and accuracy of motor actions of athletes with hearing impairments. The use of such equipment contributes to the formation of compensatory mechanisms of sensorimotor control and partial compensation for the deficit of the auditory analyzer by activating visual, kinesthetic and proprioceptive perception.

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