Journal of Physical Education

Volume 37 – Issue (3) – 2025 Open Access

P-ISSN: 2073-6452, E-ISSN: 2707-5729

https://jcope.uobaghdad.edu.iq

Impact of an Assistive Device on Arm Movement Coordination in Freestyle Swimming Among Female Physical Education Students at Baghdad University

Lina Yaseen Abdulghani [1], Soha Ali Hussain [2]

[1,2] College of Physical Education and Sport Sciences, University of Baghdad

DOI:
https://doi.org/10.37359/JOPE.V37(3)2025.2315

Article history: Received 20/ May/2025 Accepted 27/ May/2025 Available online 28/ September/2025

Abstract

The arm plays a crucial role in the freestyle swimming stroke, especially during the propulsion phase, contributing significantly to efficient movement and limb coordination. However, many learners, particularly female students at the College of Physical Education and Sport Science at Baghdad University, face difficulties mastering this skill. Traditional training methods lack immediate feedback on arm force balance and quality, limiting opportunities for simultaneous motor learning and technical improvement. To address this, a new swimming aid was developed to quantitatively measure palm pressure during swimming movements. The device includes sensors on both hands, a data processing unit, and a real-time force coordination display that provides instant biomechanical feedback. A three-month pilot study was conducted where an experimental group trained with the device, while a control group followed conventional exercises. The study aimed to evaluate the device's effectiveness in enhancing motor coordination and propulsion force balance. Results showed a statistically significant improvement, with the experimental group's average freestyle distance increasing from 14.125 to 20.687 meters, whereas the control group showed minimal change. The t-test confirmed the significance of these differences at $p < 0.05$. These findings highlight the added value of biomechanical feedback in physical education for improving motor skill performance and learning. The study provides strong evidence that this assistive device can effectively enhance swimming training techniques.

[1] College of Physical Education and Sport Sciences, University of Baghdad
lina.abd2204m@cope.uobaghdad.edu.iq, https://orcid.org/0009-0004-5487-7729.

[2] College of Physical Education and Sport Sciences, University of Baghdad.
Soha.Jomaa@cope.uobaghdad.edu.iq, https://orcid.org/0009-0007-7613-4506

Journal of Physical Education
Volume 37 – Issue (3) – 2025 Open Access
P-ISSN: 2073-6452, E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

Keywords: Biomechanical Feedback, Motor Coordination, Swimming Performance, Sensor-Based Training, Hand Propulsion Dynamics.

Introduction

These days, tools and devices have a significant part in enabling us to learn new skills. They can accelerate the acquisition of skills and offer a flexible and integrated learning environment by providing individuals with diverse technology resources (computers, and smartphones, and educational software) (Sripavithra et al., 2022). These are assisting to bring educational content in interactive and fun way that motivates the learners and promotes learning new concept and applying them better (Ahnaf Istiqlal Berutu et al., 2024).

Apart from this, the smart devices provide visualized lessons and simulated tools, the learner can learn practical and some advanced skills effectively (Prasad & Paras, 2024). Moreover, the technology enables to tailor and adjust the process of learning towards the personal needs of the learner, which increases the probability of success and the deepness and speed of mastery of skills (Amer et al., 2024; Putra et al., 2024).

Assistive devices and tools are employed in the cultivation and instruction of fundamental skills within the educational framework. Their efficacy and significance have been substantiated, particularly in enhancing the performance of athletes in physical, motor, and skill-related domains. These tools facilitate the development of sensory capabilities and motor perception, while also generating enthusiasm in learners as they engage with the equipment or navigate their environment, ultimately showcasing their competencies (BULZ et al., 2024).

Swimming is one of the oldest and most important sports activities practiced by humans, as it is considered a comprehensive sport that combines physical fitness and physical and mental endurance (Lian & Atiyah, 2024; Lin, 2024). It is also an effective way to improve overall health and stamina, as it contributes to strengthening all the muscles of the body and increasing joint flexibility (Adnan et al., 2024; Moffatt, 2017).

Arm movement is an essential element of swimming, as it plays an important role in propelling the body forward and increasing speed and efficiency. The stronger and more precise the arm movement, the more efficient the swimmer will be, allowing the learner to maintain balance in the water and increase their speed. Swimming speed depends on a periodic accelerated movement and the net balance between pushing and pulling forces and arm movement also enhances body coordination and helps reduce the resistance faced by the learner while moving through the water, improving overall swimming performance (McLeod, 2009).

Journal of Physical Education
Volume 37 – Issue (3) – 2025 Open Access
P-ISSN: 2073-6452, E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

Biomechanics, with its different kinematic and kinetic rules, has contributed to giving a distinct amount and type of reliable information that ultimately serves motor learning and other sciences, and this is done through mechanical analysis in its two qualitative ways, which depends on personal experience and observation, and quantitative, which is the most accurate, which looks into the details of the motor performance in terms of description and external form of movement as well as the causative and productive forces and thus obtaining accurate digital values, and this requires us to design and manufacture advanced technical devices and tools according to specialized scientific visions according to the type of effectiveness and performance requirements (Abdulkareem et al., 2024; Winter, 2009).

Since the arms movement is more difficult to learn because it contains three main movements (pulling, pushing and covering) and that many learners have errors in the performance of these movements, especially the water pushing movement, some learners do not perform the pushing movement correctly, that is, the push may be only with the palm without the participation of the forearm, which is achieved by the angle of the elbow joint 90 degrees(Gomes et al., 2014), This achieves a larger area to push the water or the palm is tilted so that the learner does not perform the correct push movement (Barnamehei et al., 2022), which raised the researcher's interest in this aspect due to its importance in learning freestyle swimming because without pushing there is no forward movement until a very small percentage (as contained in Newton's third law, every action has an equal and opposite reaction in the direction).

Since the main means of transportation of the swimmer in the aquatic environment represents the arms greatly and most of the female learners do not perform the movement of the arms on the correct path as explained by this research for female freestyle learners, especially for the movement of the arms (pushing force for each arm) what is the amount of that force they exert for both arms and to minimize the difference between the two forces and make them closer to the ideal to reach the best possible technical performance for all learners who will compare the skill variables, and evaluate performance before and after applying educational exercises by using the device by the researcher in learning freestyle swimming for female students (Maqableh et al., 2023).

The aim of the research is to design a device to measure the pressure force on the palm of the hand during freestyle swimming for female students of the Faculty of Physical Education and Sports Sciences and to identify the effect of the device on the balance of the pushing force of the movement of the arms of female students and to compare the performance of female students after using the device with the control sample to measure the usefulness of the device in achieving the Motor Coordination of the arms

Journal of Physical Education
Volume 37 – Issue (3) – 2025 Open Access
P-ISSN: 2073-6452, E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

The primary hypotheses of the research assert that there are no statistically significant differences between the pre-test and post-test results of the experimental and control groups regarding the attainment of motor balance in the arms during freestyle swimming among female students, and that there are no statistically significant differences in the post-test results of the experimental and control groups concerning the achievement of motor coordination in the arms during freestyle swimming for female students.

Methodology

Research Design

This study employed an experimental design including both an experimental group and a control group. The experimental group underwent a training program utilizing the designed assistive device, whereas the control group did not receive any intervention. Performance comparisons between the two groups were conducted exclusively through post-test measurements to evaluate the effect of the assistive device on enhancing arm motor balance during freestyle swimming among female students.

Research participants

The research population represents the female students of Baghdad University, Faculty of Physical Education and Sport Sciences, Jadiriya, second stage for the academic year 2024-2025.

Research sample

The study sample of (32) female students was randomly selected according to the availability of information to ensure that all target groups in terms of age and skill level are available.

The sample was divided into: Experimental group: (n=16) Students who receive the intervention using the palm pressure force measurement and the control group: (n=16) those who follow the traditional method of learning arm movement without using the device.

Components of the device

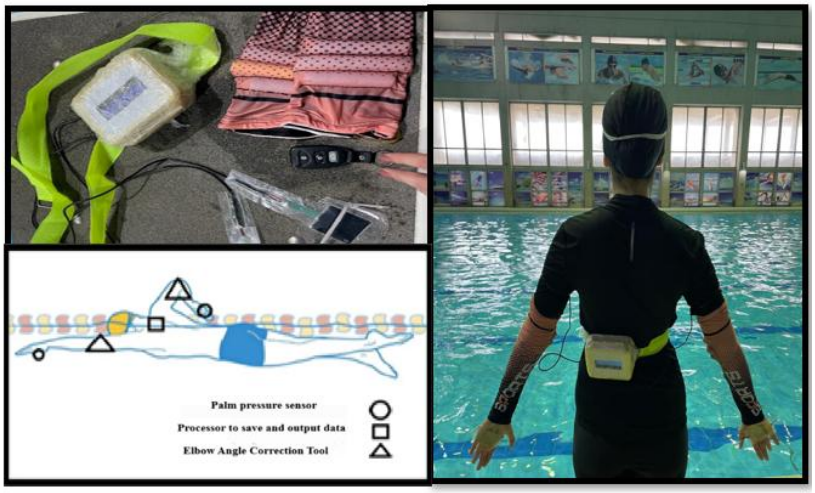
1. Two sensors are installed on the palms of the arms that read the force of the pressure applied to the learner's palm.

2. A processor to calculate the sensor reading simultaneously with each arm stroke and compare the force between the two arms.

Journal of Physical Education
Volume 37 – Issue (3) – 2025 Open Access
P-ISSN: 2073-6452, E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

3. A tool to determine and correct the angle of the elbows while pushing the arms.

A screen to show the results of the sensor reading that will give the average pressure force applied to each arm, the highest reading of the pressure rate and the difference between the right



and left arm (force symmetry = weak arm/strong arm)

Figure 1. *Shows the shape and location of the device on the learner's body*

Procedure

Thursday, 10/17/2024 was the first day of the researcher's exploratory experiment inside a small basin. The purpose of the experiment was to test the sensor's efficiency for the pressure force inside the water, determine the success of isolating the water from the sensor, and determine the extent to which the method he adopted in isolation was effective. In addition, the pushing process yielded accurate and legible readings, which were double-checked and compared to the company's recommendations. The medical palm, which was supposed to hold the sensor, was dispensed with, and the water isolator's plastic casing was adopted.

On Wednesday, June 11, 2024, in the swimming pool of the Faculty of Physical Education and Sports Sciences, the researcher ran a second exploratory experiment with a group of female students (three of whom were not part of the research sample) to determine the average number of strokes per arm over a 25-meter distance. The results showed that the average number of strokes per arm ranged from eight to fourteen. For the purpose of learning, the gadget was designed to measure the pressure force delivered to each arm (the palm sensor) using ten strokes. The student may then compare the findings from their right and left arms, to determine any differences "as described in Table 1".

Journal of Physical Education
Volume 37 – Issue (3) – 2025 Open Access
P-ISSN: 2073-6452, E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

Table 1. *Show Stroke count in freestyle with the distance of the second exploratory experiment*

No.	Stroke count in freestyle	Distance
1	10	20M
2	5	7M
3	14	25M

The test was performed for the experimental and control samples and the test was to swim freestyle for the farthest distance (Yang et al., 2025).

Purpose of the test: To measure the distance traveled by the tester when performing freestyle swimming. Instruments: Swimming pool, tape measure, stopwatch. **Test description**: The tester stands inside the pool with their back facing the edge of the pool, one leg straight with the foot on the ground while the other leg is bent backwards from the knee joint with the foot resting on the edge of the pool and performs freestyle swimming for as far as possible. **Scoring the test**: The test is recorded by calculating the distance traveled from the edge of the pelvis to the tester's feet.

The researcher developed an educational curriculum for 3 months with 24 educational units and an average of 8 units per month and 2 educational units per week (Sunday, Wednesday). The researcher's educational curriculum is only the main part of the educational unit for students whose time ranges between 25 and 30 minutes, and the transition of exercises from easy to difficult emphasizes performance with consistency and calm in order to adjust the correct paths of movements and ensure the repetition and use of feedback by the researcher with the help of readings extracted from the designed device that shows the difference in pressure force for both arms.

The pre-tests were conducted for the research sample, which numbered 32 learners, divided into two groups, experimental (16 female students) and control (16 female students), on (Wednesday) 11/12/2024, at the Faculty of Physical Education and Sport Sciences.

Journal of Physical Education
Volume 37 – Issue (3) – 2025 Open Access
P-ISSN: 2073-6452, E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

The researcher conducted the post-tests and performance evaluation on Wednesday, 12/3/2025, after completing the application of the educational curriculum under the same conditions as the pre-tests on the female learners of the sample and on the swimming pool of the college of Physical Education and Sports Sciences at university of baghdad/Jadiriya.

Data Analysis

The researcher utilized SPSS version 26 to analyze the data. Descriptive statistics, including arithmetic means, standard deviations, and skewness coefficients, were used to characterize the sample. An independent samples T-test was conducted to verify the homogeneity between the experimental and control groups before the intervention. Furthermore, the T-test was applied to compare the post-test results between the two groups. The significance level was set at 0.05.

Results

The normal distribution of the sample was performed to ensure the homogeneity of the sample in terms of the variables of height, weight and age, and the results showed that the sample is normally distributed when looking at the skewness from within (±1) "as described in Table 2".

Table 2. *shows the normal distribution of the sample*

Variable	Means	Std. Deviation	Skewness
Age	20.468	1.343668	0.241096
Weight	57.68	7.257643	0.187054
Length	160.562	6.174545	0.291735

Equivalence and homogeneity tests were conducted for the experimental and control research samples in the variables to start with a similar starting position and the results showed non-significant and greater than (0.05) indicating the sample is equivalent "as described in Table 3"

Table 3. *shows the equivalence between the experimental and control groups in the research variables*

Variable	Experimental group		Control group		F	Sig.	T	Sig. (2-tailed)	Mean Difference	Std. Error Difference
	Means	SD	Means	SD	0.570	0.456	0.103	0.918	0.062	0.606

Journal of Physical Education
Volume 37 – Issue (3) – 2025 Open Access
P-ISSN: 2073-6452, E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

freestyle for the farthest distance	14.125	1.707	14.187	1.721

* at a significance level of 0.05 with a degree of freedom of 30

The results of the posttest between the experimental and control groups, which showed statistically significant differences for the experimental group "as described in Table 4"

Table 4. *shows the results of the post-tests for the experimental and control groups*

Variable	Experimental group		Control group		F value	Sig.	T value	Sig. (2-tailed)	Mean Difference	Std. Error Difference
freestyle for the farthest distance	**Means**	**SD**	**Means**	**SD**	11.811	0.002	7.764	0.000	6.125	0.788
	20.687	2.821	14.562	1.412						

* at a significance level of 0.05 with a degree of freedom of 30

Discussion

The study's results demonstrated the efficacy of the device intended to measure palm pressure force during freestyle swimming in enhancing the motor performance of female students' arms, as the statistical data revealed significant differences favouring the experimental group in the farthest distance swimming test. The findings are reflected in the significant enhancement observed in the mean distance travelled, indicating that the device facilitated improved motor coordination and an equitable distribution of force between the arms, enabling students to navigate successfully and precisely in water.

The improvement benefits from the reasonable design of the device, which will returned the prompt feedback of the pressing exertion of the two arms for the users, so the users can feel and regulate the strength difference between the both arms during self-training. In particular, prompt feedback with respect to error correction may also be an important factor for improvement of near-term and better performance for the early learning process Some studies have reported that prompt feedback with respect to error correction may be a key factor to facilitate fast learning

Journal of Physical Education
Volume 37 – Issue (3) – 2025 Open Access
P-ISSN: 2073-6452, E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

and good performance in the skills-learning task (Magill & Anderson, 2012; Schmidt & Lee, 2019; Zaher Yahya et al., 2024).

Furthermore, the hands-on use of the device in a natural teaching setting allowed students to connect the biomechanical analysis of performance to the learning process, to heightened kinesthetic sensitivity and to finer details of the arm motion. Significance of modern technology along with kinetic analysis for enhancing performance in game and sports which needs muscle coordination with high preciseness (Prasad & Paras, 2024).

The findings are compatible with the kinetic theory of force, and propulsion in swimming because of the increased palm pressure contributing to attain more effective water push and this translated in enhanced speed and kinetic efficacy (Koga et al., 2022). This finding is notable because arm motion is the largest contributor to movement through water with freestyle swimming, and correcting the kinematics of this movement produces noticeable differences in overall performance (Abdulkareem et al., 2017; Cohen et al., 2015; ITO, 2007).

Based on the aforementioned, we can highlight that the use of smart technologies, in particular smart devices for sensing analysis and motor analysis, is a favorable initiative to enhance fine motor skills and the professional learning environment in the sport context. These findings suggest the potential for the extension of the use of the device to other populations or to other similar water sports, as well as the development of further kinematic indicators like the propulsion angle or the movement time (Abdulkareem et al., 2025).

Conclusions

The results of this study underscore the practical importance of employing assistive technology in sports education, particularly in teaching and enhancing fine motor skills such as hand grip strength during freestyle swimming. The designed device demonstrated high precision in recording the exerted force during performance, which enabled the participants to identify weaknesses in their movement and work on correcting them through immediate feedback provided by the device.

The use of this device contributed significantly to the improvement of motor coordination between the arms among the participants, reflecting the effectiveness of technological intervention in enhancing the quality of motor learning. The progress achieved by the experimental group compared to the control group indicates that custom-designed devices for evaluating and monitoring detailed motor performance can play a vital role in both teaching and training settings.

Journal of Physical Education
Volume 37 – Issue (3) – 2025 Open Access
P-ISSN: 2073-6452, E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

These results confirm the validity of integrating biomechanical information with an applied educational design and advocate a further development of novel technological tools in the area of PE. Its application is particularly useful in novice learners, when is required a clear feedback to adequately assess the task.

Therefore, this research not only helps to develop the students' mobility skills, but also accepts teaching different ball games skills with similar devices. It also demonstrates the possibility of using local educational tools made in-house as cheap, efficient alternatives to expensive imported tools, thereby encouraging independence and inventiveness in learning institutions.

Recommendations

1. Adopting the device in educational curricula for swimming to help learners gain a better understanding of proper arm mechanics and improve pushing force symmetry.
2. Expanding the use of biomechanical measurement tools in other swimming styles and across different age groups to evaluate their effectiveness in diverse learning contexts.
3. Encouraging collaboration between sports technologists and educators to further develop assistive devices that support motor learning and technique correction.
4. Conducting follow-up studies with larger and more varied samples to validate the current findings and explore long-term performance improvements.

Journal of Physical Education
Volume 37 – Issue (3) – 2025 Open Access
P-ISSN: 2073-6452, E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

References

Abdulghani, L. Y., Abdulghani, M. Y., & Abdulkareem, O. W. (2025). Designing a palm pressure measurement device to improve motor coordination in freestyle swimming among female students. Journal of Physical Education and Sport, 25(7), 1506–1513. https://doi.org/10.7752/jpes.2025.07168

Abdulhussain, A. A., Abdulkareem, O. W., Atiyah, H. S., Jaber, O. H., Ghanim, M. R., Hammood, A. H., & Saleh, Y. M. (2025). The Impact of Jesko's Strategy with Sequential Exercises on Learning the Skill of Dribbling in Basketball. Annals of Applied Sport Science, 0–0. https://doi.org/10.61186/AASSJOURNAL.1550

Abdulkareem, O. W., & Ali Hassan, M. F. (2025). impact of mental games on improving shooting accuracy among young basketball players in Iraqi clubs. Scientific Journal of Sport and Performance, 4(3), 342–351. https://doi.org/10.55860/OHNP7224

Abdulkareem, O. W., & Sattar Jabbar, H. (2025). Comparative Biomechanical Analysis of Three-Point Shooting Between Elite Iraqi Basketball Players and International Counterparts. Journal of Sport Biomechanics. https://doi.org/10.61186/JSportBiomech.11.3.326

Abdulkareem, O. W., Fadhel, M., Hassan, A., Amer, A., & Atiyah, H. (2024). A COMPARATIVE STUDY OF THE MOST IMPORTANT PERSONALITY TRAITS BETWEEN PRACTITIONERS AND NON-PRACTITIONERS OF SPORTS ACTIVITY. https://proximusjournal.com/index.php/PJSSPE

Abdulkareem, O. W., Hameed, H., & Al-Hussein, A. (2017). Analytical-Comparative Study of Some Kinematical Variables Of Jump Shot and Shooting in Youth Basketball Players. In Article in Journal of Physical Education. https://www.researchgate.net/publication/378564080

Abdulkareem, O. W., Jabbar, H. S., & Obaid, A. J. (2025). The Effect of Soft Toss Machine Training on Some Kinematic Variables and backhand accuracy of Tennis Players U16 years. Journal of Physical Education (20736452), 37(1), 190–205. https://doi.org/10.37359/JOPE.V37(1)2025.2147

Ahnaf Istiqlal Berutu, Mafira Roza, & Riki Naldi Hsb. (2024). Peran Guru Dalam Menggunakan Media Pembelajaran Interaktif Untuk Membangun Motivasi dan Minat Belajar Siswa. Inspirasi Dunia: Jurnal Riset Pendidikan Dan Bahasa, 3(3), 88–97. https://doi.org/10.58192/insdun.v3i3.2249

Barnamehei, H., Renganathan, G., Aflatounian, F., Fatemigarakani, S., Maboudmanesh, A., Fatahzadeh, A., Shaabani, A., & Kurita, Y. (2022). Effect of Medial-Lateral, Inferior-Superior, and Rotational Positions of Palms on Muscle Recruitment during the Push-Up Exercise. Applied Sciences, 12(19), 10178. https://doi.org/10.3390/app121910178

Journal of Physical Education
Volume 37 – Issue (3) – 2025 Open Access
P-ISSN: 2073-6452, E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

BULZ, A. M., ȘANDRA, M., SABĂU, A. M., GROSU, E. F., & BULZ, G. C. (2024). Enhancing motor skills and coordination in middle schoolers through innovative physical education programs. GeoSport for Society, 21(2), 115–125. https://doi.org/10.30892/gss.2104-112

Cohen, R. C. Z., Cleary, P. W., Mason, B. R., & Pease, D. L. (2015). The Role of the Hand During Freestyle Swimming. Journal of Biomechanical Engineering, 137(11). https://doi.org/10.1115/1.4031586

Easa, F. A. W., Shihab, G. M., & Kahdim, M. J. (2022). the Effect of Training Network Training in Two Ways, High Interval Training and Repetition To Develop Speed Endurance Adapt Heart Rate and Achieve 5000 Meters Youth. Revista iberoamericana de psicología del ejercicio y el deporte, 17(4), 239-241.

Gomes, L. E., Melo, M. de O., Tremea, V. W., Torre, M. La, Silva, Y. O. da, Castro, F. de S., & Loss, J. F. (2014). Position of arm and forearm, and elbow flexion during performance of the sculling technique: Technical recommendation versus actual performance. Motriz: Revista de Educação Física, 20, 33–41.

Hussain, F. M., Shuhaib, M. H., & Hassan, M. F. A. (2024). Psychological Toughness and its Relationship to Some Coordination, Physical Abilities and Accuracy of Some Basic Skills Performance Among The Iraqi Junior National Handball Team Players. International Journal of Disabilities Sports and Health Sciences, 7(Special Issue 2): The Second International Scientific Conference: Sports for Health and Sustainable Development,(SHSD, 2024)), 330-336.

ITO, S. (2007). Optimal Armstroke for Swimming of Freestyle. TRANSACTIONS OF THE JAPAN SOCIETY OF MECHANICAL ENGINEERS Series B, 73(734), 2051–2057. https://doi.org/10.1299/kikaib.73.2051

Kadhim, M. J. (2023). Examining The Relationship Between Social Classes And The Culture Of Poverty: A Case Study. International Journal of Social Trends, 1(1), 23-27.

Koga, D., Tsunokawa, T., Sengoku, Y., Homoto, K., Nakazono, Y., & Takagi, H. (2022). Relationship Between Hand Kinematics, Hand Hydrodynamic Pressure Distribution and Hand Propulsive Force in Sprint Front Crawl Swimming. Frontiers in Sports and Active Living, 4. https://doi.org/10.3389/fspor.2022.786459

Lian, D., & Atiyah, H. (2024). Physical Activity, Sleep and Health-related quality of life (HRQOL) for college students in Iraq. Journal of Physical Education, 36(1), 223–206. https://doi.org/10.37359/JOPE.V36(1)2024.2064

Lin, H. (2024). Research on the analysis of training methods in the sport of swimming. Theoretical and Natural Science, 35(1), 182–188. https://doi.org/10.54254/2753-8818/35/20240945

Magill, R. A., & Anderson, D. I. (2012). The roles and uses of augmented feedback in motor skill acquisition. Skill Acquisition in Sport: Research, Theory and Practice, 3–21.

Journal of Physical Education

Volume 37 – Issue (3) – 2025 Open Access

P-ISSN: 2073-6452, E-ISSN: 2707-5729

https://jcope.uobaghdad.edu.iq

Maqableh, M., Alwidyan, H., & Aljawlan, W. (2023). The Effect of an Educational Program by Using Assistive Devices on Improving the Performance Level of Crawl Stroke Swimming among Female Students of the Faculty of Physical Education. Educational and Psychological Sciences Series, 2(1), 67–93. https://doi.org/10.59759/educational.v2i1.123

McLeod, I. A. (2009). Swimming anatomy. Human Kinetics.

Moffatt, F. (2017). The individual physical health benefits of swimming: a literature review. The Health & Wellbeing Benefits of Swimming, 8–25.

Prasad, Dr. S. S., & Paras, Dr. A. K. (2024). ADVANCING PHYSICAL EDUCATION AND SPORTS THROUGH TECHNOLOGY. In Futuristic Trends in Social Sciences Volume 3 Book 20 (pp. 137–142). Iterative International Publishers, Selfypage Developers Pvt Ltd. https://doi.org/10.58532/V3BBSO20P7CH4

Putra, C. A., Permadi, A. S., & Setiawan, M. A. (2024). Information technology innovation in sports learning: understanding global trends and challenges. Retos, 58, 844–854. https://doi.org/10.47197/retos.v58.106485

Schmidt, R. A., & Lee, T. D. (2019). Motor learning and performance 6th edition with web study guide-loose-leaf edition: From principles to application. Human Kinetics Publishers.

Sripavithra, C. K., Kirubanand, V. B., & Paulose, J. (2022). Role of Information Tools in Teaching and Learning. SHS Web of Conferences, 139, 03003. https://doi.org/10.1051/shsconf/202213903003

Winter, D. A. (2009). Biomechanics and motor control of human movement. John wiley & sons.

Yang, L., Gao, B., Chen, Y., Xu, Q., Zhou, J., & Tang, Q. (2025). Comparing The Effects of Maximal Strength Training, Plyometric Training, and Muscular Endurance Training on Swimming-Specific Performance Measures: A Randomized Parallel Controlled Study in Young Swimmers. Journal of Sports Science and Medicine, 128–141. https://doi.org/10.52082/jssm.2025.128

Zaher Yahya, S., Kazem Abdul Rida, B., & Waleed Abdulkareem, O. (2024). effect of a laser device on some biomechanical variables of the rotational phase in the achievement of 100 m freestyle swimming for the Iraqi team (16-18 years old). Scientific Journal of Sport and Performance, 3(4), 507–512. https://doi.org/10.55860/zhow5603