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Article

Impact of conjugated material modified intelligent taekwondo equipment on the physical fitness of college students

Xiaodan Yang[1,2,*], Qing He[3]

[1] Sports Department, Haojing College of Shaanxi University of Science & Technology, Xi'an 712046, Shaanxi, China
[2] School of Educational Management, Graduate School, Bansomdejchaopraya Rajabhat University, Bangkok 10600, Thailand
[3] Department of Public Sports, Soochow College, Suzhou 215031, China
*** Corresponding author:** Xiaodan Yang, yxd20241011@163.com

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Abstract: The cultivation of physical fitness among college students plays an important role in their comprehensive development and healthy growth process. Traditional training methods and equipment lack flexibility, making it difficult to effectively improve the athletic ability and physical fitness of college students. In order to improve the physical health level of college students and improve the quality and level of their sports training, this article conducted in-depth research on intelligent Taekwondo equipment modified with conjugated materials and its impact on the physical fitness of college students. This article first analyzed the requirements for intelligent Taekwondo equipment, and then based on this, graphene was used as the main material to prepare it using electrochemical stripping method, and modified by doping nitrogen atoms. Finally, the modified graphene was used in the design of intelligent Taekwondo equipment. To verify the application effect of modified graphene intelligent Taekwondo equipment, this article conducted testing and analysis on it. The results showed that compared to conventional training methods, students who applied modified graphene intelligent Taekwondo equipment for auxiliary training improved their final test scores in flexibility, endurance, and muscle strength indicators by 0.96 points, 1.02 points, and 0.65 points, respectively. The conclusion indicated that the intelligent Taekwondo equipment modified with graphene conjugated materials had a positive impact on the improvement of physical fitness of college students, which helped to improve their physical health level.

Keywords: intelligent taekwondo equipment; conjugated materials; physical fitness; modified graphene; college sports

1. Introduction

The changes in modern lifestyles and habits have made the demand for improving the physical fitness of college students increasingly urgent [1]. Taekwondo, as a comprehensive combat sport, plays an important role in enhancing student muscle strength, enhancing body coordination and flexibility. The traditional Taekwondo training method is single and difficult to comprehensively evaluate physical fitness. With the development of science, technology, and chemical materials, conjugated materials have made great progress [2,3]. Conjugated materials refer to compounds with continuous conjugated π electron systems, which are widely used in electronic devices, sensors, and smart materials due to their excellent physical and mechanical properties. Its typical representatives include polymers and small molecule conjugated compounds. Conjugated materials have high conductivity and plasticity. By modifying them and combining them with intelligent technology, intelligent Taekwondo equipment can be developed to achieve real-time perception and recording of student sports training status, and provide personalized training plans. It has important practical value in improving the physical fitness of college students and promoting the scientific development of Taekwondo sports.

With the rapid development and application of new technologies such as motion perception and sensing, intelligent sports equipment has also achieved certain results. Kim Kijin integrated Taekwondo with artificial intelligence, virtual reality technology, and other technologies to create intelligent Taekwondo sports. Through research, it has been shown that intelligent Taekwondo sports can protect human body shape, promote physical fitness, and improve athlete performance [4]. To improve the effectiveness of Taekwondo strength training, Liu Jiaojiao developed a data-driven modeling Cormax system using a fuzzy rule system to predict training performance. The results indicated that the Cormax system performed well in improving the maximum strength and speed of athletes, effectively enhancing training effectiveness and helping to develop and improve training programs [5]. Chu William Cheng-Chung believed that sports science faces challenges in various aspects such as data collection, accuracy in knowledge formation, and availability of equipment. He provided a feasible solution for different movements based on artificial intelligence technology, and applied the solution to these challenges using weight training as an example. Finally, the feasibility of the solution was verified through good experimental results [6]. Qiu Sen adopted a motion reconstruction method based on gradient descent to fuse sensor data. By unconstrained traversal of the roots, he combined human posture with foot trajectory to achieve synchronous reconstruction of posture and displacement. The experimental results showed that the motion estimation error was well controlled, which could provide effective basis for sports training [7]. Although existing intelligent sports equipment has certain auxiliary capabilities for sports training, it is still difficult to meet the current needs of sports training in terms of motion perception and functional characteristics of sports equipment. Many materials struggle to strike a balance between flexibility and conductivity, limiting the comfort and performance of the equipment. Secondly, insufficient durability leads to easy damage during high-intensity exercise, which limits the popularity and application of intelligent sports equipment.

The development of material engineering provides more possibilities for improving the perception and functional characteristics of intelligent sports equipment. Huang Zhenjia synthesized a novel organic photothermal doped conjugated polymer using donor monomer diketopyrrole and acceptor monomer through palladium catalyzed cross coupling polymerization, and applied it in photoresponsive liquid crystal elastomers. The results showed excellent photothermal effects, repeatable shape changes, and ultrafast response time, which can effectively assist motion [8]. Shalaby Mohammed Nader believed that research and development activities in advanced materials engineering and nanotechnology can improve the versatility of smart nano textiles, thin film composite oxides, nanoparticles, carbon nanotubes, and conductive polymers required for sports performance and equipment. He found that the use of materials engineering and nanotechnology can effectively improve sports performance and device value by monitoring and evaluating the new nanotechnology wearable flexible strain sensors required for physiological and biomechanical variables of athletes [9]. Li Jian analyzed the application of fiber-reinforced composite materials in sports equipment and their impact on the development of social sports. Through studying the surface morphology and physical and mechanical properties of glass fiber epoxy resin composites containing alumina nanofillers, it was found that nanocomposites can help improve the functionality of sports equipment [10]. Multi functional materials can provide real-time perception and rapid response to environmental changes during movement, enhancing the application value of devices. However, most studies still have certain limitations in terms of device training experience and adaptability.

In order to improve the physical fitness of college students and enhance their health level, this article conducted in-depth research on the intelligent Taekwondo equipment modified with conjugated materials and its impact on the physical fitness of college students. This article used graphene as the main material, improved it by doping nitrogen atoms, and designed an intelligent Taekwondo sensing device. In the experimental analysis, this article tested it from two aspects: performance and functionality. In performance testing, compared to pre modified graphene intelligent Taekwondo equipment, graphene intelligent Taekwondo equipment modified with nitrogen atoms had better electrical performance and sensitivity; in functional testing, compared to the control group of students who used conventional training methods, the experimental group of students who used the equipment in this article improved their final test scores for flexibility, endurance, and muscle strength by 0.96 points, 1.02 points, and 0.65 points, respectively. The modified graphene intelligent Taekwondo equipment also showed ideal experience level survey results. The innovation of this article lies in the modification of conjugated materials, which enhances the conductivity and flexibility of intelligent taekwondo equipment, making it more comfortable and adaptable during exercise. Combined with advanced sensing technology, the equipment can monitor athletes' physical status in real time and provide personalized training feedback. This intelligent application not only improves training effectiveness, but also helps athletes better manage their physical functions. In practical applications, intelligent Taekwondo equipment modified with conjugated materials can effectively enhance the training effectiveness of college students and improve their physical fitness.

2. Intelligent taekwondo equipment based on conjugated material modification

2.1. Requirements for intelligent taekwondo equipment

Taekwondo is a traditional combat event that primarily involves kicking, hitting, and defending [11]. It is not only a competitive sports event, but also a comprehensive physical training method [12]. Currently, college students generally lack physical exercise [13]. Taekwondo combines speed, strength, agility, and technique, and is a comprehensive sport. Through continuous practice and exercise, it can effectively improve the physical function and quality of college students. Intelligent Taekwondo equipment is a device designed to combine modern technology with traditional Taekwondo training techniques, with the main purpose of improving practice effectiveness and skill level. This equipment combines sensor technology, real-time data analysis, and daily training to provide more accurate and effective guidance for college students to exercise their physical fitness. In practical applications, the design and development requirements of intelligent Taekwondo equipment mainly include:

(1) Functionality

Intelligent Taekwondo equipment requires precise motion information acquisition and analysis functions. It should achieve effective collection of real-time information such as the strength and speed of moving objects, in order to provide more accurate feedback for physical training. In addition, it must have the ability to recognize various actions to assist moving objects in improving their skills and strategies. Taekwondo is usually taught according to certain standards and courses, and the collective teaching environment and physical activity courses in universities are difficult to meet the differentiated training needs of different students [14,15]. It is also necessary to assist in implementing personalized training programs based on the individual differences of different college students. The functional requirements of the equipment also include reliable sensing technology to ensure the accuracy and real-time performance of motion analysis.

(2) Comfort

The comfort of intelligent Taekwondo equipment directly affects the effectiveness of physical fitness training for college students. In equipment design, ergonomic requirements should be met to ensure comfort and freedom during exercise, so as not to restrict the range and speed of athlete movements. The weight of equipment materials should be light, ensuring a certain degree of flexibility and adaptability, and avoiding unnecessary constraints and discomfort to moving objects.

(3) Stability

In order to ensure the long-term operation of intelligent Taekwondo equipment, its structural stability is crucial. In terms of material selection, emphasis should be placed on high strength, high wear resistance, and high durability to meet the high-intensity and high-frequency training needs of Taekwondo. In structural design, attention should be paid to the reliability of material properties to ensure that the equipment can withstand the impact and explosive forces generated by moving objects in motion. Given the unique nature of Taekwondo, intelligent Taekwondo equipment should ensure that the structure is not damaged and its performance is not affected by continuous kicking and impact.

2.2. Preparation and modification of conjugated materials

Conjugated materials are a type of material with a special electronic structure, in which the orbitals in the molecular structure can form a continuous conjugated system, thereby achieving free electron transfer [16,17]. This unique structure endows it with excellent optoelectronic properties, chemical stability, flexibility, and plasticity [18].

Graphene is the most widely used conjugated material. Its structure is shown in **Figure 1**.

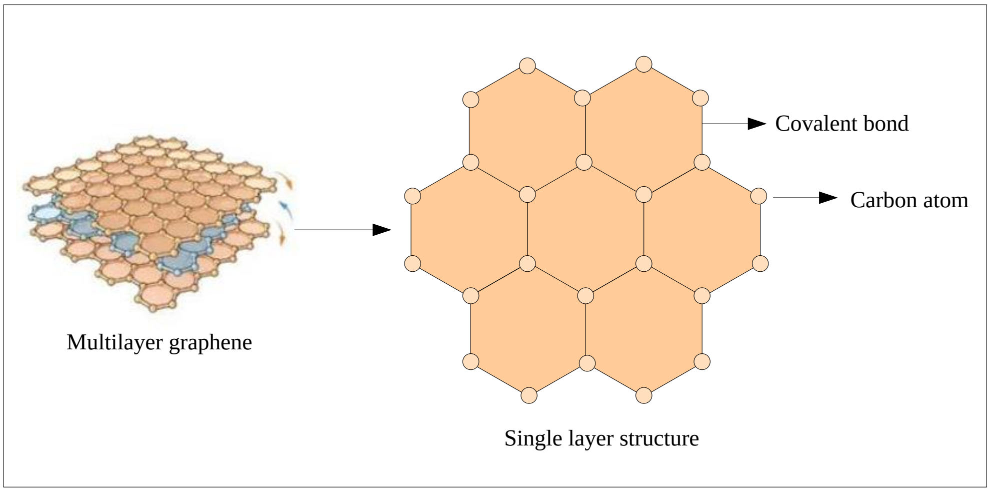

Figure 1. Graphene structure.

From **Figure 1**, it can be seen that graphene is a densely packed hexagonal structure composed of a single layer of carbon atoms, presenting a two-dimensional honeycomb structure on the plane. It has excellent mechanical properties and stability. Under external stress, graphene can achieve atomic scale deformation without the need for structural rearrangement [19,20]. The main component of graphene is carbon, and the strong covalent bonds between carbon atoms give it high strength and stability. In the actual preparation process, graphene may contain some vacancies, edge defects, and impurities such as oxygen and nitrogen. Graphene carbon atoms only have one non bonded electron on the p_z-orbital, which is connected to the non bonded electrons on the adjacent carbon atom's p_z-orbital, resulting in delocalized large π-bonds, leaving its electrons in a semi filled state, thereby exhibiting excellent conductivity and optical properties [21]. This article takes it as the main material, prepares and modifies it, and designs an intelligent Taekwondo sensing device using modified graphene.

2.2.1. Preparation of graphene

At present, the common preparation methods for graphene mainly include vapor deposition, oxidation-reduction, electrochemical exfoliation, and epitaxial growth. Among them, the vapor deposition method utilizes an organic carbon source for thermal decomposition, and then prepares carbon atoms through vapor deposition to generate graphene. This method is costly and requires the removal of the substrate material, making the preparation process more complex. The oxidation-reduction method uses graphite as the starting material and achieves the preparation of graphene by changing the van der Waals force between graphite layers. However, it has limitations such as long preparation time and strong substrate dependence. The epitaxial growth rule refers to the direct growth of one or several layers of graphene on a single crystal substrate, which requires a long time and has strong substrate dependence. The electrochemical stripping method is fast, simple, and highly controllable, resulting in graphene with high crystallinity and low impurity content. Therefore, this article adopts the electrochemical exfoliation method for the preparation of graphene. The main materials used for preparation are shown in **Table 1**.

Table 1. Main materials for graphene preparation.

Sequence	Material	Specification or purity level
1	Graphite paper	3 centimeters*2 centimeters*0.05 centimeters
2	Sulfuric acid	Analytical reagent (AR)
3	Ammonium sulfate	AR
4	Deionized water	AR
5	Ethanol absolute	AR

From **Table 1**, it can be seen that graphite paper, sulfuric acid, ammonium sulfate, deionized water, and anhydrous ethanol are mainly used in the preparation process of graphene.

During the preparation process, the surface of the graphite paper should be cleaned thoroughly to ensure that there is no dust or impurities. Then, an electrolyte solution is prepared, which includes sulfuric acid, ammonium sulfate, deionized water, and anhydrous ethanol in a certain proportion. On this basis, an electrolytic cell is established, and a working electrode and a reference electrode are installed. The set parameters are shown in **Table 2**.

Table 2. Experimental parameters for graphene preparation.

Sequence	Parameter	Specifications
1	Current density	5 milliampere per square meter
2	Room temperature	25 ℃
3	Reaction time	30 min
4	Electrode spacing	2 centimeters

According to the parameter settings in **Table 2**, the subsequent preparation process is divided into two stages: electrochemical intercalation and exfoliation. Using graphite paper as the anode and platinum electrode as the cathode, they are separated at intervals of 2 centimeters. In the electrochemical intercalation stage, the graphite electrode is immersed in an electrolyte solution at a depth of about 2.5 centimeters. A DC (direct-current) power supply is added to the electrode, and it is energized for 10 minutes. Then, the graphite paper is removed and rinsed with deionized water to remove residual sulfuric acid. During the stripping phase, it is continued to apply DC power and set the power on time to 20 min. The current first flows out from the anode, forming a positive potential that oxidizes the anode graphite into C^{n+}. Then, through the electrostatic repulsion on the anode, the lattice boundary layer of the graphite is opened. Under the action of an external electric field, a large number of sulfate ions and water molecules are introduced into the graphite layer, increasing the volume of graphite and reducing the van der Waals interaction force. The electrolysis of water on the cathode produces hydrogen ions with strong nucleophilic activity, which effectively attack the sp^2 hybrid carbon atoms at the boundaries of graphite crystals and grain boundaries. The gas generated during the electrolysis process also seeps into the electrode, causing the interlayer spacing of graphite to increase, further expanding, and ultimately separating from the negative electrode graphite. Through filtration, the stripped graphene is washed multiple times with water, and then dried for 12 h at a temperature of 60 ℃ to prepare graphene powder.

2.2.2. Graphene modification

Conjugated structures typically involve carbon atom sequences with alternating single and double bonds [22,23]. Due to the high electronegativity of nitrogen atoms and their similar radii to carbon, substituting appropriate nitrogen atoms for carbon atoms in the material can make nitrogen atoms electron donors, thereby enhancing the surface charge mobility of the material [24]. By adding nitrogen atoms, the conductivity of graphene can be improved, enhancing its conductivity and thus enhancing its application value in the field of electronic devices [25]. This article introduces nitrogen atoms into the graphene structure to replace some carbon atoms, thereby forming a nitrogen doped graphene structure and achieving graphene modification. The main materials used for modification are shown in **Table 3**.

Table 3. Main materials used for modification.

Sequence	Material	Specification
1	2,6-Diaminopyridine (DAP)	0.3 grams
2	Deionized water	350 milliliters
3	Aqueous ammonia	1 milliliter
4	Hydrazine hydrate	1 milliliter
5	Ethanol absolute	100 milliliters
6	Graphene	300 milligrams

In the process of graphene modification, first, 300 milligrams of graphene powder are dissolved in 150 milliliters of deionized water, then 1 milliliter of ammonia water is added, and the mixed solution is subjected to ultrasonic treatment for 2 h to generate a homogeneous graphene suspension. In 100 milliliters of deionized water, 0.3 grams of DAP are added and subjected to magnetic stirring until it is fully dissolved. The DAP solution is added to the graphene suspension and stirred continuously in a three necked flask. It is refluxed at a temperature of 100 ℃ for 2 h to obtain a stable mixed solution. Next, 1 milliliter of hydrazine hydrate solution containing 70% mass ratio is added dropwise to the mixed solution and subjected to reflux operation at a temperature of 100 ℃ for 1 h to remove oxidation groups from graphene. On this basis, deionized water and anhydrous ethanol are used to repeatedly wash the black suspension obtained, remove residual DAP and hydrazine hydrate, and undergo freeze-drying treatment to obtain modified graphene material samples.

2.3. Design of intelligent taekwondo sensing devices

In the design of intelligent Taekwondo sensing devices, polydimethylsiloxane (PDMS) with high elasticity is selected as the flexible matrix, and a good porous PDMS structure is constructed. In the preparation process, this article uses sugar particles as templates to help form pore structures. Firstly, an appropriate amount of sugar particles are weighed and added to a container containing PDMS. Then, a curing agent is added to the container and stirred evenly with a glass rod for 30 min to completely mix the sugar particles with PDMS. Then, the mixed solution is loaded into the mold and placed in a constant temperature box for curing treatment. The temperature condition is set to 70 ℃ and the curing time is 2 h. After the solidification treatment is completed, in order to fully dissolve the sugar particles, the sugar particles/PDMS solid are placed in a beaker and heated and stirred using a stirrer under water bath conditions. The temperature is set to 50 ℃ and the stirring time is set to 24 h. Under heating and stirring, both the surface and internal sugar particles are dissolved by water molecules, forming a porous PDMS structure elastomer.

A porous graphene PDMS sensing material is prepared by depositing modified graphene onto porous PDMS. Anhydrous ethanol is added to a container containing modified graphene material samples, and the two are thoroughly mixed to form a modified graphene dispersion with a certain concentration. The pre prepared porous PDMS structure elastomer is immersed in a modified graphene dispersion for 10 min. Then, the soaked porous PDMS structure elastomer is placed in a constant temperature oven for drying treatment, with a drying temperature of 80 ℃ and a drying time of 10 min. The soaking and drying steps are repeated 5 times, and graphene can be deposited on the porous PDMS structure as a sensing material.

The prepared porous graphene PDMS sensing material is cut into a rectangular prism with a length × width × height of 22 mm × 15 mm × 10 mm to serve as the dielectric layer for intelligent Taekwondo sensing devices. The design process of the sensing device is shown in **Figure 2**.

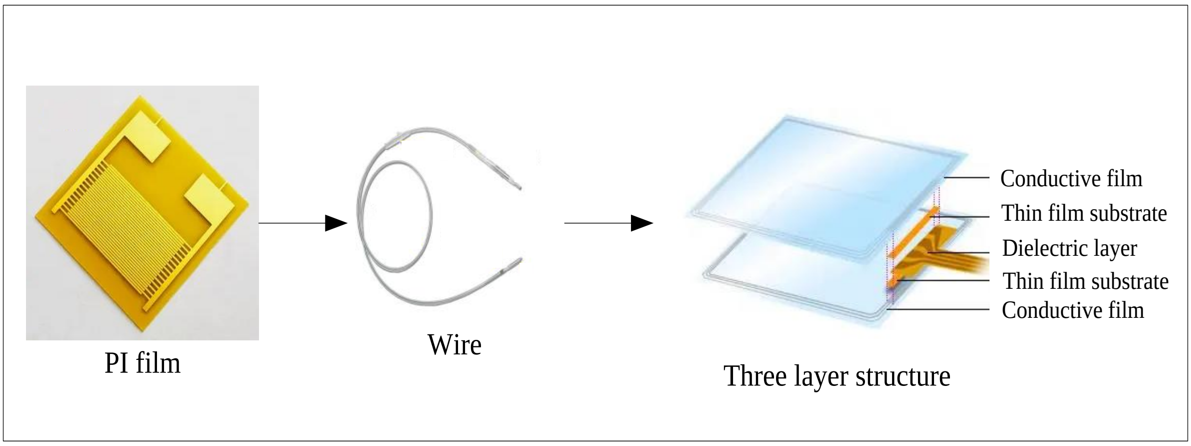

Figure 2. Design process of sensing equipment.

In **Figure 2**, firstly, the laser etching method is utilized to fabricate a flexible polyimide (PI) film into a capacitor type electrode plate with a length × width of 10 millimeters × 7 millimeters, and the wire is directed towards the other end of the electrode end face structure. On this basis, two conductive films of different thicknesses are selected, and a porous graphene PDMS dielectric layer is inserted between the upper and lower electrodes to form a multi-layer flexible stress-strain sensor. The flexible strain sensor is then placed on the Taekwondo equipment. In the design of sensing devices, flexible polyimide film and porous graphene PDMS dielectric layer are used to endow the sensor with excellent flexibility and lightweight characteristics, which can adapt to the dynamic changes of sports equipment without affecting the activities of athletes. The design of multi-layer electrode structures and porous dielectric materials can enhance the sensitivity and stability of sensors, improve their ability to sense small strains and pressure changes, and meet the requirements of high-precision measurement.

Factors such as pressure, temperature, humidity, and doping can all alter the electrical properties of graphene, especially under pressure. Graphene is subjected to stress, which can regulate the energy band of graphene, thereby achieving control over its electrical properties. Considering the transition energy between adjacent π electrons in the graphene structure, the energy dispersion of graphene near the Fermi plane is expressed by the formula:

$$E(v) = E_0 \pm \frac{3}{2} x_0 \alpha |v - v_k| \tag{1}$$

Among them, E is the electron transition energy of the Fermi level, and v_k is the Fermi wave vector. In the graphene structure, due to quantum confinement, the electronic energy levels are distributed along a discontinuous straight line, so the band structure is related to the position of the Dirac cone. Under external stress, the position of the Dirac cone shifts, resulting in the energy difference between the lowest point of the conduction band and the highest point of the valence band in graphene. The relationship between the conduction band and the valence band is obtained [26,27]:

$$E(v) = E_0 \pm \sqrt{9 x_0^2 \alpha^2 v^2 + E_b^2} \tag{2}$$

E_b is set as the bandgap. When external pressure acts on graphene, its adjacent carbon atoms have the same transition energy. When external pressure is applied to graphene, it generates strain, causing the movement of electron and hole carriers inside, thereby forming energy bands inside. The energy band composed of electron carriers is the conduction band, while the energy band composed of hole carriers is the valence band. There is an energy level jump between the two, resulting in an energy difference. The edge energy E_e of graphene band is expressed as [28]:

$$E_e = E_k \pm E_b \tag{3}$$

From the formula, it can be seen that E_e is determined by the Fermi level E_k and the band gap E_b. In the formula, $+$ represents the conduction band in the graphene energy band, and $-$ represents the valence band in the graphene energy band. As graphene deforms, the positions of the lowest point of the conduction band and the highest point of the valence band also change, and the deformation potential constant is defined as [29]:

$$\frac{\partial E_e}{\partial \varepsilon} = \frac{\partial E_k}{\partial \varepsilon} \pm \frac{1}{2} \frac{\partial E_b}{\partial \varepsilon} \tag{4}$$

The energy changes at the lowest point of the conduction band and the highest point of the valence band are selected to calculate the deformation potential constant, and thus perceive and evaluate the motion state of the moving object. It is mainly used to describe the changes in the position of the lowest point of the conduction band and the highest point of the valence band of graphene when subjected to external forces or deformation. By analyzing the influence of deformation on the band structure, the characteristics of graphene materials can be better designed and controlled to meet the application needs of intelligent taekwondo equipment.

3. Performance and functional testing of intelligent taekwondo equipment based on modified graphene

To verify the effect of modified graphene on the physical fitness of college students in intelligent Taekwondo equipment, this paper conducted performance and functional tests on it.

3.1. Performance testing

Performance testing mainly includes testing the current-voltage characteristics and sensitivity of intelligent Taekwondo equipment based on modified graphene.

(1) Current-voltage characteristic test

In the current-voltage characteristic test, a current source and a voltage tester were connected to the input and output terminals of the intelligent Taekwondo equipment, respectively. The test parameters are set as shown in **Table 4**.

Table 4. Current-voltage characteristic test parameters.

Sequence	Parameter	Specifications
1	Starting voltage	−0.8 volts (V)
2	End voltage	0.8 V
3	Step	0.02 V
4	Temperature range	20 ℃–25 ℃
5	Humidity range	40%–60%

According to **Table 4**, in the test, the starting voltage and ending voltage of this article were −0.8 V and 0.8 V, respectively. On the basis of the set parameters, multiple measurements were taken at each voltage point, and the current-voltage variation curve was recorded. The recorded current-voltage data was imported into the analysis software for curve fitting. To highlight the experimental results, this article compared the current-voltage characteristics of graphene intelligent Taekwondo equipment before and after modification. The final result is shown in **Figure 3**.

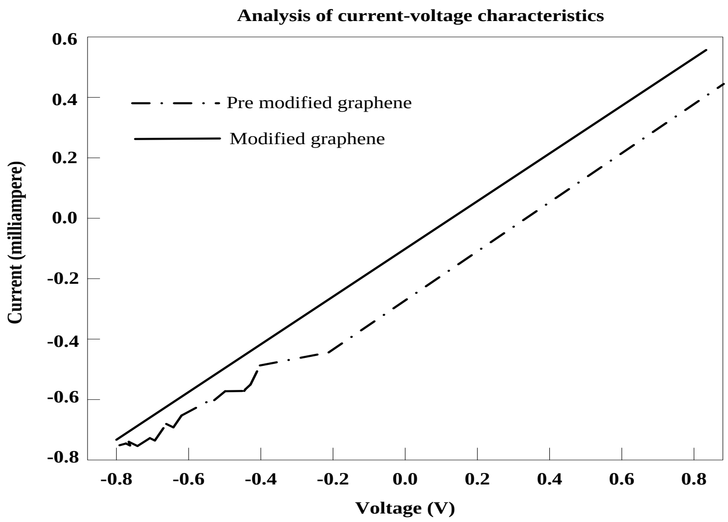

Figure 3. Current-voltage characteristic test results.

From **Figure 3**, it can be seen that under the current-voltage characteristic test, there were significant differences in voltage and current between the graphene intelligent Taekwondo equipment before and after modification. Among them, the modified graphene equipment showed a good linear relationship between voltage and current, while the pre modified graphene exhibited certain fluctuations in the voltage range of −0.8 V to −0.2 V. When the applied voltage exceeded −0.2 V, the overall trend of change was roughly the same as that of the modified graphene equipment. From the fitting results, it can be seen that the modified graphene intelligent Taekwondo equipment had good electrical performance.

(2) Sensitivity testing

The sensitivity test aims to verify the motion perception effect of graphene intelligent Taekwondo equipment before and after modification. In the experiment, this article achieved the detection of equipment stress, converted the tensile strain of equipment under different pressure environmental conditions into a resistance signal output, and measured the relevant data under gradually applying pressure and gradually releasing pressure. The sensitivity of intelligent Taekwondo equipment was tested using hysteresis as a measure. The final result is shown in **Figure 4**.

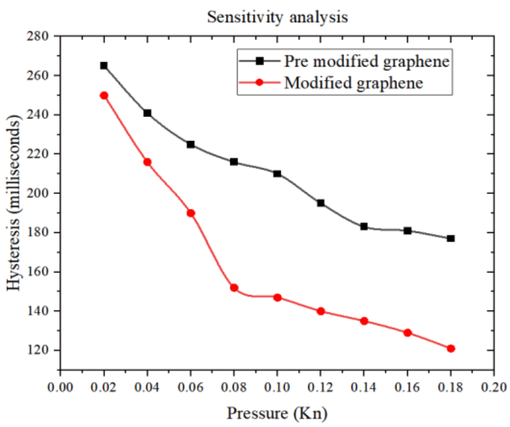

Figure 4. Sensitivity test results.

In **Figure 4**, the horizontal axis represents pressure in kilonewton (Kn), and the vertical axis represents hysteresis in milliseconds. From the sensitivity curve changes of graphene intelligent Taekwondo equipment before and after modification, it can be seen that the hysteresis results decreased with increasing pressure. From the specific comparison results, it can be seen that the graphene intelligent Taekwondo equipment modified by doping nitrogen atoms had higher sensitivity. Its hysteresis result under initial pressure (0.02Kn) was 250 milliseconds, and its hysteresis result under final pressure (0.18Kn) was 121 milliseconds; the hysteresis result of the graphene intelligent Taekwondo device before modification was 265 milliseconds under initial pressure conditions, and 177 milliseconds under final pressure conditions. Compared to the graphene intelligent Taekwondo equipment before modification, the graphene intelligent Taekwondo equipment modified with nitrogen atoms can perceive changes in sports training faster and more accurately, better grasp and feedback students' movements and skills.

3.2. Functional testing

The functional testing aims to verify the training effectiveness and experience level of the modified graphene intelligent Taekwondo device among college students. In the functional testing, this article took sophomore computer science students from a certain university as the sample object. 100 students were randomly selected from this student group to form the sample set of this article, and they were divided into an experimental group (50 students) and a control group (50 students). Among them, the experimental group students used modified graphene based intelligent Taekwondo equipment for Taekwondo training, while the control group students used conventional training methods.

(1) Training effectiveness

The training period was set to 16 weeks, and the training effectiveness of students was tested every two weeks during the training period. The training effectiveness testing indicators mainly include flexibility, endurance, and muscle strength, which are directly related to the performance and skill development of athletes in competitions and have certain representativeness. The testing method adopted standardized testing. Due to the differences in standardized testing of various indicators, this article converted different test results into unified scoring results based on student performance, with a scoring range of 1–10 points. The final result is shown in **Figure 5**.

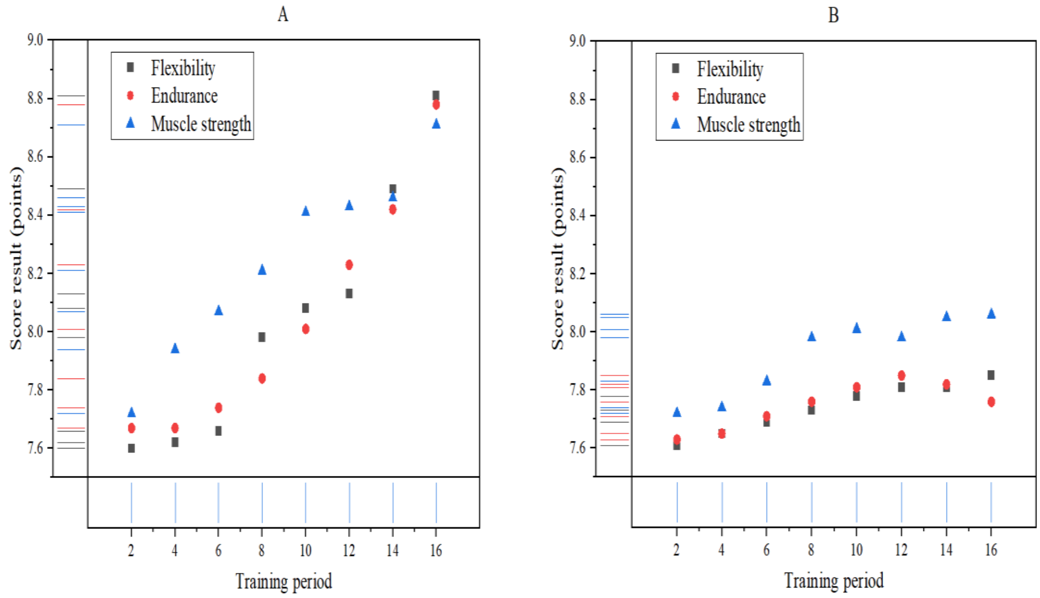

Figure 5. Training effect rating.

Figure 5A shows the training effectiveness scores of the experimental group students;

Figure 5B shows the training effectiveness scores of the control group students.

From the training effect score in **Figure 5**, it can be seen that there was not much difference in the flexibility, endurance, and muscle strength scores between the two groups of students in the initial training test stage, but there was a significant difference in the later stage of training. In **Figure 5A**, the flexibility, endurance, and muscle strength scores of the experimental group students during the initial training test stage were 7.60 points, 7.67 points, and 7.72 points, respectively. Under the training based on modified graphene intelligent Taekwondo equipment, their final flexibility, endurance, and muscle strength test scores reached 8.81 points, 8.78 points, and 8.71 points, respectively. In **Figure 5B**, the control group students scored 7.60 points, 7.67 points, and 7.72 points for each indicator during the initial training and testing stage. Under conventional training methods, their final test scores for each indicator were 7.85 points, 7.76 points, and 8.06 points, respectively. Compared to the control group students, the experimental group students improved their final test scores in flexibility, endurance, and muscle strength by 0.96 points, 1.02 points, and 0.65 points, respectively. The specific comparative experimental results indicate that the training method of smart devices can effectively promote the improvement of students' physical fitness. The relatively small improvement in the control group indicates that traditional training methods have limited impact on student development.

(2) Experience level

After the end of the training cycle, a survey was conducted on the training experience of the experimental group students under the modified graphene intelligent Taekwondo equipment. The survey indicators and student attitude grading are shown in **Table 5**.

From **Table 5**, it can be seen that the attitude levels of students were divided into four levels. Based on the survey results, this article statistically analyzed the proportion of student attitude levels under each survey indicator. The final result is shown in **Figure 6**.

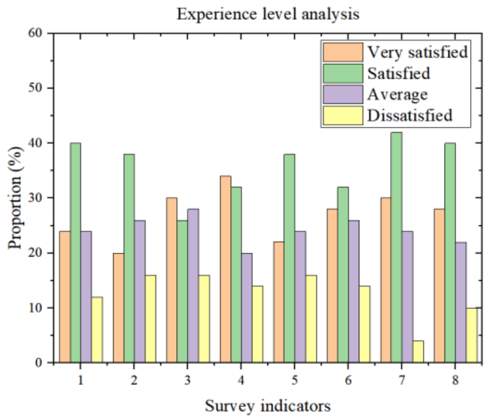

Figure 6. Results of experience level survey.

Table 5. Survey content and student attitude grading.

Sequence	Survey indicators	Grading of student attitudes
1	Device perception	Very satisfied
2	Operating experience	
3	Fun of training	Satisfied
4	Motivation	
5	Personalized effects	Average
6	Long term usage intention	
7	Improvement of physical function and quality	Dissatisfied
8	Achievement of personal goals	

From **Figure 6**, it can be seen that the intelligent Taekwondo equipment based on modified graphene had a relatively ideal experience level among the student population. Among them, the survey indicators with the highest proportion of very satisfied attitude levels were motivation, fun of training, and improvement of physical function and quality, with specific proportions reaching 34%, 30%, and 30%, respectively. From this survey result, it can be seen that with the assistance of modified graphene intelligent Taekwondo equipment, the fun and motivation of student sports training have been effectively improved, and their physical fitness has been significantly enhanced.

4. Discussion

In the performance and functional testing of intelligent Taekwondo equipment based on modified graphene, this article verifies the current-voltage characteristics, sensitivity, training effectiveness, and experience level from four aspects.

In the current-voltage characteristic test, compared to the graphene intelligent Taekwondo device before modification, the device modified with nitrogen atoms shows more ideal linear characteristics between current and voltage. In practical applications, modified graphene has excellent conductivity, and intelligent Taekwondo equipment can effectively perceive the movement status of students during training through its excellent electrical performance, improving the effectiveness of physical fitness training for students.

In sensitivity testing, under different pressure conditions, the modified graphene intelligent Taekwondo equipment has lower hysteresis and stronger sensitivity. It can quickly capture the movements and changes of student training, record and analyze every subtle movement of students in real time, and provide more accurate basis for training feedback and plan adjustment.

In the training effectiveness test, compared with students trained using conventional training methods, students trained with intelligent Taekwondo equipment based on modified graphene show higher scores in the final test of flexibility, endurance, and muscle strength. This indicates that the equipment in this article is beneficial for improving the physical fitness of college students, improving their skills and health levels.

In the experience level test, the intelligent Taekwondo equipment based on modified graphene has relatively ideal survey results. The modified graphene can effectively improve the comfort and adaptability of the intelligent Taekwondo equipment, providing students with a more durable and flexible experience for Taekwondo training, and enhancing their sports enthusiasm.

5. Conclusions

With the development of society and the advancement of technology, college students generally suffer from problems such as lack of exercise, which has seriously affected their exercise ability and health level. In order to improve the physical fitness of college students and promote their comprehensive development, this article combined modified graphene conjugated materials to construct intelligent Taekwondo equipment and deeply studied its impact on the physical fitness of college students. The intelligent Taekwondo equipment based on modified graphene conjugated materials has ideal electrical performance and sensitivity. Applying it to assist college students in training not only effectively improves their flexibility, endurance, and muscle strength, but also enhances their enjoyment and enthusiasm for sports. The intelligent Taekwondo equipment modified with conjugated materials in this article has a good effect on improving the physical fitness of college students, but there are still limitations in the research process. In the experimental analysis, this article did not deeply consider the impact of other influencing factors such as diet, psychological state, and lifestyle habits on the improvement of physical fitness, and the issue of equipment adaptability also needs to be further verified by expanding the sample size and time range. In future research, in-depth research would be considered from the perspectives of sample control variables and long-term effect evaluation to promote the cultivation of comprehensive qualities among college students.

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