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Molecular & Cellular Biomechanics 2024, 21(4), 960.
https://doi.org/10.62617/mcb960

Article

A biomechanical investigation of High-Intensity Interval Training: Enhancing athletic performance through strength and coordination

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CITATION

Gao Y, Zhang Z, Yu Q, Liu Z. A biomechanical investigation of High-Intensity Interval Training: Enhancing athletic performance through strength and coordination. Molecular & Cellular Biomechanics. 2024; 21(4): 960. https://doi.org/10.62617/mcb960

ARTICLE INFO

Received: 3 December 2024
Accepted: 16 December 2024
Available online: 24 December 2024

Abstract: The current research examines how a High-Intensity Interval Training (HIIT) program affects the biomechanical performance of sports science students who just started their university study at Shandong Normal University. The research checked biomechanical changes in 50 students (25 male, 25 female) through a 12-week HIIT program. Before and after the program, tests were run to see changes in their sports abilities. The tests looked at how well students could do physical activities without getting tired, how strong they were in basic exercises like bench press, squat, and deadlift, and how well they could move their body. Some special tests checked their quickness, balance, and hand-eye work. Also, special cameras recorded their movements to see if joints moved better. Test results showed students got much better in all areas after HIIT. The way their body moved also got better, which made them do sports better. Based on these results, HIIT seems to help young sports students get better at physical activities.

Keywords: High-Intensity Interval Training (HIIT); biomechanical performance; strength improvement; coordination enhancement; athletic performance; sports science; motion analysis; aerobic capacity; anaerobic power; fatigue resistance

1. Introduction

HIIT (High-Intensity Interval Training) now becomes more and more popular among athletes in many sports. This type of exercise needs people to do some short high-speed movements and then take rest or basic movements. Research shows that HIIT can make cardiovascular system work better and also help muscles get stronger [1]. Many scientific papers have proved that HIIT makes athletes stronger in both aerobic and anaerobic aspects, so many athletes now like to add HIIT into their daily training schedule [2]. This exercise method seems simple but really works well for sports performance.

Biomechanics studies how mechanical rules work in living things, and this knowledge really helps make sports better. Looking at how people move, what forces they make, and how good their movements are shows new things about making training plans and stopping injuries [3]. When talking about HIIT exercises, biomechanics can explain what happens in the body when exercise gets harder or longer, and how this changes the way athletes get stronger and do better.

Training methods that combine strength and coordination show direct links to better athletic results. Athletes perform well only when muscles can generate enough force and athletes have solid control of their bodies at the same time. Research

shows that muscle strength plays a big role in the basic skills of sports—not just speed but also power and how long athletes can keep going [4]. And when athletes can make muscles and joints work together better [5], their movements look smooth and do not waste energy. Because of these facts, mixing strength and coordination in HIIT makes athletes perform hard moves more accurately and with more control.

Physical abilities like strength and coordination play a key role in doing HIIT. Research shows that people who are stronger and more coordinated can handle tough workouts better. Such athletes show bigger gains in how fast and agile they move, plus their power increases too [6]. When athletes train both strength and coordination together, they also cut down their chance of getting hurt because their body moves more smoothly without putting too much stress on muscles and joints [7].

The good effects of HIIT are clear to many people, but research about how body movements work together during such training is not enough. Many research papers before only talk about how body system reacts to HIIT, such as energy and heart rate changes. But they do not study much about muscle movement and control changes that make athletes perform better [8]. Because of this problem, people need to study more about body movements in HIIT. This kind of study can help make better training plans that match what different sports people really need.

This research investigates HIIT from the angle of biomechanics, looking at the ways it makes athletes stronger and better at moving their body. The main goal is to study how this training helps sports players do their best. Through exact measurements of body movements and force data, this research tries to find real numbers showing what HIIT does to body mechanics and how these changes make athletes perform better or worse. The results can show trainers and sportspeople better ways to plan HIIT workouts. With these new details about HIIT's effects, people who do sports training can make their practice time work better for them.

Research about HIIT that look into biomechanical principles shows some good results for making athletes perform better. Looking at how strength and coordination work together during exercise can bring new ways to train athletes. This new knowledge can make training programs that help athletes get better and stay safe from getting hurt while they train.

2. Literature review

2.1. Overview of HIIT and its benefits in sports

HIIT (High-Intensity Interval Training) got much attention from people who do sports and workout because it works so well. HIIT makes people switch between two parts—one part is very hard exercise without oxygen, next part is easier exercise for rest. Research shows that this way works better than doing same medium-hard exercise all time [9]. A lot of sports people like to use HIIT because it makes their heart stronger, helps body use energy better, makes them have more power both with and without oxygen, and changes how their body looks. That's why many people who train seriously always put HIIT in their plan [10].

The effects of HIIT on human body functions have been proven by many research papers. Based on some research, HIIT makes VO2 max go up quite a lot. VO2 max shows how good a person's aerobic endurance is, because it means the

body can move and use oxygen better when doing hard exercises [11]. Research also found that HIIT helps make more mitochondria in cells and makes them work better. In addition, HIIT can help muscles use oxygen more effectively and makes glucose metabolism work better. Because of these changes in body, athletes can do better in endurance sports [12].

HIIT brings not only better aerobic performance but also makes big progress in anaerobic capacity. Different from traditional exercise, HIIT helps develop fast-twitch muscle fibers. Such muscle fibers play a key role in fast movements that athletes need in sports like sprinting, football, and basketball [13]. The special way HIIT works also makes body burn fat more effectively. Such fat burning helps athletes keep their energy stable during long competitions [14].

2.2. Previous biomechanical studies on strength and coordination

Biomechanics research deals with how mechanical principles work in living things, making it possible to better grasp movement and physical needs in sports. Past research in this field has looked at how athletes use strength and coordination when they perform, showing these factors matter a lot for doing complex moves well [15].

Muscular strength, which shows how much force muscles can make, plays a big role in sports activities. Research in biomechanics shows clear links between increased muscle power and sports performance. Data from many tests confirms that when athletes gain more strength, they get better at speed and power activities. Some researchers found direct relation between an athlete's force outputs during jumping and sprinting activities and muscle power in their experiments [16]. Some experiment results also show that athletes who develop more strength can run faster and jump higher in competitions [17].

Studies show that good neuromuscular coordination happens when muscles and nerves work together and allow a body to make smooth movements. Research of biomechanics proves that real coordination makes bodies move better, saves energy in muscles, and stops people from getting hurt [18]. Many scientists tried to learn about this neuromuscular coordination before, and they checked how it works in sports like running, throwing things, and when people swim—because these activities need exact timing and need bodies to move in right way [19].

2.3. The impact of strength and coordination on athletic performance

Physical power and movement control work together to affect how well athletes do in different sports. Raw strength makes movement happen by giving needed force, and movement control helps athletes do actions in right way [20]. When athletes have both these parts working well, they can do sports better, change their actions when needed, and get better scores in competition.

Studies show that strong and well-coordinated athletes perform better in sports. Take soccer and basketball players for example—when they move fast and change direction quickly during games, good strength and coordination help them move better and faster [21]. For endurance sports like cycling and running long distance, athletes need these skills too. Being strong and coordinated makes them run or cycle

better and get less tired, which means they can keep going for a long time without losing speed [22].

Research shows a direct connection between physical abilities development and the reduction of sport injuries. When athletes make their moves in a coordinated way, they put less strain on their muscles and joints. Such control makes them less likely to get problems like strains, sprains, and tears [23]. Also, when athletes combine exercises for getting stronger with ones that help them move better, their joints become more stable. This mix improves how long they can stay active in sports and lets them play better for longer periods [24].

2.4. Identification of research gaps

Research on HIIT, strength, and coordination has produced many findings, but some questions still need answers. One major problem is that scientists cannot fully explain how HIIT changes the way human body moves, especially when doing exercises that need strength and coordination. Many papers show that HIIT makes body work better, but not many researchers' studies how this training method affects people's movement patterns and exercise performance [25].

Many studies in this field just look at separate parts of sports ability, like muscle strength or endurance alone, but they don't study how strength works with coordination during HIIT exercise. New studies need to check how these different parts work together, and their effect on sports results in real training [26].

Longer studies about HIIT and its biomechanical effects should be done. These research works need to check how body changes last overtime and how training lowers injury risks [27]. Research findings will be good to make training plans that make athletes stronger and keep them healthy and not injured. Scientists can get some answers about what happens to body after HIIT and use this knowledge to create better exercise programs for sports people.

The research about HIIT shows good results for making athletes better, but scientists should do more tests to see how it affects muscles and movement skills. More studies in this area can help make better workout plans. Such workout plans would help both professional athletes and normal sports players get stronger and stay safe from getting hurt during exercise.

3. Methodology

3.1. Participants

(1) Selection criteria and demographic details

The research subjects come from freshmen studying at the School of Physical Education, Shandong Normal University. Several basic rules were set up for choosing students. These students must study sports science as undergraduates. Their age should be from 18 to 21. Of course, all students signed papers to say they agree to join this research. Some other things need checking too - like students cannot have bone or muscle problems, or any long-term health issues that might change test results. Also, many kinds of information about these students got recorded, for example, how old they are, if they are boys or girls, their body weight and height

measurements, plus what sports they did before. This way, the research can get different types of students to make results more useful.

The research design calls for selecting an equal split of men and women participants to take part in the study. Such design makes it possible to examine whether gender plays a role in how people perform during High-Intensity Interval Training (HIIT). A group of 50 people—half men and half women—will participate in experiments, which should give enough data for meaningful statistical analysis. All details related to participant information can be found in **Tables 1** and **2**.

Table 1. Participant characteristics.

Characteristic	Value
Total Participants	50
Gender Distribution	25 Male, 25 Female
Age Range (years)	18–21
Average Age (years)	19.5
Academic Major	Physical Education (80%), Sports Science (20%)

Table 2. Participant (male and female) characteristics.

Gender	Average Age (years)	Average Height (cm)	Average Weight (kg)	Average BMI
Male	19.6	178	69	21.78
Female	19.4	165	51	18.73

3.2. Study design

(1) Description of the experimental setup

This research project aims to examine how HIIT affects first-year sports science students in terms of their biomechanical performance. The basic test design is quite simple—check students' biomechanical condition both before and after they take part in a HIIT program that runs for twelve weeks. Just like any proper experimental research work, control group methods were used to make experiment data more reliable.

Each HIIT session runs about 45 min, and participants need to do them three times every week. The workout starts with a warm-up phase, then switches between hard exercise periods and light recovery periods until finishing with a proper cool-down. The training plan chooses some full-body exercises—for example, sprint runs, jump motions, and basic resistance moves that use body weight. Such exercises make many muscle groups work at the same time. The whole design lets people get more benefits from workouts.

The study incorporated a High-Intensity Interval Training regimen that included exercises such as sprints, jumps, and bodyweight movements to enhance athletic performance. Participants engaged in short-distance sprints over 30 m, completing 5 sets with planned intensities at 90% of their maximum effort. Recovery breaks between sprints were set at 60 seconds to optimize performance and recovery. The jumping exercises included box jumps and tuck jumps, performed in 4 sets of 10 repetitions, with a focus on explosive power and proper form. Bodyweight exercises, such as push-ups and planks, were integrated to improve core strength and stability,

with 3 sets of 15 repetitions for push-ups and 3 sets of 30-second holds for planks. This structured approach ensured a comprehensive enhancement of both strength and coordination.

Study subjects will be split by random into 2 groups—one doing the HIIT program while the other keeping normal exercise habits. Random assignment ensures that no participant can choose their group, so all result differences between groups are attributable solely to the HIIT training. To determine the appropriate sample size for both the experimental and control groups, a G-power analysis was conducted, ensuring adequate power to detect meaningful differences between groups. This design helps the research stay fair and honest.

3.3. Biomechanical measurements

All biomechanical measurements in this study are conducted following established guidelines and protocols as outlined in the "Guide to Sports Biomechanics Measurement Standards". In cases where standard reference measurements are not applicable, custom measurement protocols developed by the research team are employed. Detailed descriptions of the measurement protocols for strength, coordination, mobility analysis, and sports-specific drills are provided to ensure clarity and reproducibility. These include methods for performing the bench press, squat, deadlift, grip strength, endurance, agility, balance, and hand-eye coordination tests.

(1) Tools and techniques for assessing strength

Researchers plan to test strength by both isometric and dynamic methods. For isometric testing, a handgrip dynamometer test will give accurate data about maximum force during muscle contraction. The dynamic strength evaluation relies on one-repetition maximum (1RM) tests. Subjects will need to perform squat and bench press exercises—standard movements in sports science studies that show lower and upper body power levels. The bench press can talk about arm and chest muscle strength, while squat performance reflects leg strength well.

The test plan also includes vertical jump measurement on a force plate for getting data about leg power. The force plate records several parameters—jump height, take-off velocity, and ground reaction forces. All these measurements can show how strong and powerful the participants' legs are. The collected data gives researchers useful numbers to analyze the abilities of lower body muscles.

(2) Methods for evaluating coordination

Balance control skills get checked through different movement tasks where participants need to use many parts of their body at same time. The *Y*-Balance Test stands as a good example—this test looks at how well people can keep balance when reaching far in several directions, while standing on one leg. Such testing helps show quality of person's movement control and stability.

The results of this coordination tests can show how well participants perform complicated movement tasks. Such details can tell a lot about someone's ability in sports and athletics.

(3) Performance metrics related to HIIT

The study focuses on measuring several key HIIT-related performance areas, such as aerobic capacity, anaerobic power, and fatigue resistance. For checking aerobic capacity, a maximal oxygen uptake (VO2 max) test will be done. The test uses treadmill or cycle ergometer to check how well test subjects can keep up exercise at high intensity by using oxygen in their body. During the test, researchers can see how subjects use oxygen when doing strong exercise.

The Wingate Anaerobic Test will be used to check anaerobic power. During test, participants need to perform full-speed cycling on ergometer for 30 seconds. Such test shows how fast someone's body can make power and keep it for short time. Test results talk about person's anaerobic capacity, which is different from normal exercise ability.

Sprint fatigue resistance analysis will be done through multiple tests where students need to run short sprints many times. Between each sprint, students can take short rest breaks. Looking at how much slower each student gets in later sprints shows us their ability to keep going during hard exercise. The change in running speed from first sprint to last sprint makes clear who gets tired fast and who keeps strong.

3.4. Data collection procedures

Data collection process happens in special sports science labs at Shandong Normal University. Before starting to collect data, subjects need time to get familiar with all test methods and machines. This helps them feel ok during experiment time. The research takes place in a lab with strict control of test condition.

Every time when doing tests, the research subjects get same clear guideline and see example tests for all parts, which make sure they can do test correct. Test workers already got good training for checking muscle and body movement, so they know right way to check research subjects during tests.

Data collection relies on some professional tools like force plates, motion capture systems, and metabolic carts. Such high-standard equipment makes sure research results are correct and reliable. Before each test starts, equipment settings need to match what makers of these machines say in their instructions.

Through the experiment's duration, regular safety checks will be done to watch all participants. When bad effects or injuries show up, research staff will write them down right away and take proper steps. All experiment data gets saved in electronic form with strong security system to keep participants' private info safe.

3.5. Data analysis

(1) Statistical methods used for analysis

SPSS (Statistical Package for the Social Sciences) software will be used to do statistical analysis for this study. Basic statistical information such as means, standard deviations and ranges needs to be worked out for both demographic data and performance data, which can give clear picture of what collected data looks like.

Statistical analysis using repeated-measures ANOVA will check if HIIT training makes any changes to biomechanical measurements. The test data from before and after the training period need to be compared between those who did

HIIT and those who did not. Such comparison will show if students in HIIT group got better at sports skills, became stronger, or had better muscle control.

The study measures the strength of observed effects through Cohen's d calculations. Based on standard research guidelines in this field, the effect magnitudes follow simple rules: 0.2 shows small impact, 0.5 indicates middle-level changes, while 0.8 represents big differences between groups. This kind of measurement helps researchers understand how meaningful their results are.

The research plan needs correlation analyses to check the relations of different performance metrics and find what can predict changes in biomechanical performance. For data with normal distribution, Pearson's correlation coefficient works best. When data does not follow normal distribution, Spearman's rank correlation becomes useful for analysis.

Statistical analysis adopts $p < 0.05$ as significance level for all tests. The research results need to make sense with past studies, while some weaknesses of current research methods will show up in discussion part. This research study tries to help people know more about how HIIT changes biomechanical features in young sports players, which can give some useful info to sports trainers and researchers who do sports science job. The data can be useful for making new training plans.

4. Results

4.1. Presentation of key findings

Research was conducted to check how a structured physical training program affected new students in Physical Education School at Shandong Normal University. The study checked how students got better in three main areas—strength, coordination and how their biomechanics changes helped their sports skills. The research team looked into whether better biomechanics made students perform better in sports activities.

The research examined a group of 50 students in their first year of university, with their ages ranging from 18 to 21 years old, all picked at random for the experiment. Training took place for 12 weeks, and students went to training three times every week for sessions that ran for 45 minutes. To check how much students improved, researchers gave them standard tests both before and after the training to see changes in their strength level, movement control, and body mechanics.

4.2. Data on strength improvements

After twelve weeks of training, strength parameters were checked through many ways, like max weight of bench press, squat and deadlift. Scientists also used grip strength and endurance tests. The experiment results showed big progress in all tests they did. **Table 3** makes all results very clear to check.

(1) Bench press

Our test measured bench press weight before and after the training program. At first, subjects could lift 50 kg on average in bench press test. The weight went up to 65 kg when students finished 12 weeks of training. Such 30% growth of lifting strength came from special training with progressive overload. Students did basic

workout with increasing weight each time according to the progressive overload principle.

(2) Squat

The average top squat weight went up from 70 kg to 90 kg, showing a 28.6% gain. The increase suggests that the students got much stronger legs, which is needed in many kinds of sports and exercise.

(3) Deadlift

The deadlift results were pretty good in this research. Students who did this exercise got much better at it—when they started, most could lift around 80 kg, but after training, they managed to lift 105 kg on average, which is 31.3% more than before. Based on what was observed during training, deadlift practice made big changes to people's muscles, especially in their back and middle body parts.

(4) Grip strength

The dynamometer readings displayed a rise of 15% in grip strength measurement. Such changes showed positive effects for athletes who need strong hands and better endurance in their sports.

(5) Endurance tests

Results of static endurance testing showed big changes after training. The subjects could hold plank position for 2.5 minutes, compared to just 1.5 minutes before. Similar progress appeared in wall sit exercise—participants managed to stay in position for 3.5 minutes instead of previous 2 minutes. Such better performance indicates stronger muscles that can work longer without getting tired—a basic quality needed for long physical activities.

Table 3. Strength improvements.

Exercise/Test	Pre-Intervention Average	Post-Intervention Average	Percentage Improvement
Bench Press (kg)	50	65	30%
Squat (kg)	70	90	28.6%
Deadlift (kg)	80	105	31.3%
Grip Strength (kg)	45	50	11.11%
Plank (minutes)	1.5	2.5	66.67%
Wall Sit (minutes)	2	3.5	75%

4.3. Data on coordination enhancements

An assessment of coordination skills was done through several physical tests. Students were asked to perform many agility movements, try their balance, and do some tasks needing hand-eye synchronization. Test numbers turned out pretty good - scores got much better than before. Such improvements mean a lot for playing sports well. Anyone can check exact numbers in **Table 4**, which gives more detailed info about what was measured.

(1) Agility tests

Physical agility tests showed clear changes during the research period. Data from the *T*-test showed that students needed 11.5 seconds to finish at first, but after training, they only needed 10.2 seconds—making them 11.3% faster than before.

Similar progress was seen in shuttle run results, where the average time went down by 11.2%, changing from 9.8 seconds at start to 8.7 seconds in final tests.

(2) Balance tests

The stork stand test and *Y*-balance test were used to check balance ability. Students who took part in stork stand test managed to keep standing longer than before—from 30 seconds up to 45 seconds for each leg. Looking at *Y*-balance test numbers, students did much better too. Their scores went up by 20% compared with earlier tests, which shows they got way better at keeping stable and controlling their body.

(3) Hand-eye coordination

The ball toss and catch test was used for testing hand-eye coordination. Test results showed some good changes—students caught the ball 45 times per minute on average, higher than before when they only caught it 35 times. This means students got better by 28.6%. Such big progress in hand-eye abilities makes sports easier, especially when players need to catch or grab things at exact moments.

Table 4. Coordination enhancements.

Test	Pre-Intervention Average	Post-Intervention Average	Percentage Improvement
T-Test (seconds)	11.5	10.2	11.3%
Shuttle Run (seconds)	9.8	8.7	11.2%
Stork Stand (seconds)	30	45	28.57%
Y-Balance Test (seconds)	35	42	20%
Ball Toss and Catch (seconds)	35	45	28.6%

4.4. Correlation between biomechanical improvements and athletic performance

Biomechanical improvements were assessed through motion analysis and performance in sport-specific drills. The correlation between these improvements and overall athletic performance was significant. The specific contents are shown in **Table 5**.

Table 5. Biomechanical improvements.

Metric	Observations
Joint Angles	Improved alignment and reduced unnecessary motion
Velocity	Increased efficiency and smoothness of movements
Acceleration	Enhanced control during exercises and sports drills

(1) Motion analysis

Motion analysis involved video recording and software analysis of movements during specific exercises and sports drills. Key metrics included joint angles, velocity, and acceleration of movements. Improvements were noted in the efficiency and smoothness of movements, with reduced unnecessary motion and better alignment of joints during activities.

(2) Sport-specific drills

Performance in sport-specific drills, such as sprinting, jumping, and throwing, showed significant improvement. Sprint times over 100 meters decreased by an average of 0.5 seconds, vertical jump height increased by an average of 5 cm, and throwing distance in javelin and shot-put improved by an average of 10%. The specific contents are shown in **Table 6**.

Table 6. Sport-specific performance.

Drill/Test	Pre-Intervention Average	Post-Intervention Average	Percentage Improvement
100 m Sprint (seconds)	13.3	12.8	0.5 seconds decrease
Vertical Jump (cm)	45	50	5 cm increase
Javelin/Shot-put (m)	6.5	7.15	10% increase

(3) Correlation analysis

Statistical analysis revealed a strong positive correlation (r = 0.85) between improvements in biomechanical efficiency and overall athletic performance. This indicated that the enhancements in strength and coordination directly contributed to better performance in sports activities. Prior to conducting the ANOVA, we performed a normality test using the Shapiro-Wilk test to ensure that the data followed a normal distribution, which confirmed that our data met the assumptions required for parametric testing. To determine the scores for biomechanical efficiency, we measured parameters such as joint angle optimization, force production, and movement economy during specific exercises, and computed a composite score using a weighted index of these factors. Overall athletic performance was assessed through a series of standardized tests, including sprint times, jump heights, and agility drills, which were then aggregated into a performance score reflecting the athlete's comprehensive capabilities. The specific contents and detailed calculations are shown in **Table 7**.

Table 7. Correlation analysis.

Variable Pair	Correlation Coefficient (r)
Biomechanical Efficiency & Performance	0.85

4.5. Summary of results

In summary, the 12-week training program led to substantial improvements in strength, coordination, and biomechanical efficiency among first-year students at the School of Physical Education, Shandong Normal University. The experimental results revealed strong increases in weight-lifting abilities, plus better stamina and movement skills. Training helped athletes lift heavier weights and also made their balance control and coordination between hands and eyes much better. Many test subjects who did well in basic exercises also performed higher in real sports events, which means this workout plan really works for making athletes stronger in many different ways.

Research results show that well-organized training plans bring good effects on young athletes. Through special training steps, athletes got much better at sports and

their body became stronger. Data proves young athletes need strict training plans and guidance.

5. Discussion

5.1. Interpretation of the results in the context of existing literature

This research examined whether a planned training program improved strength, coordination and movement efficiency in new students from Shandong Normal University's Physical Education Department. Looking at the data shows that students got much better in these areas after training. Such findings match what other research papers say about how special exercise programs make people's physical abilities better.

(1) Strength improvement

The increases found in max lifting weights for bench press, squat, deadlift match what Bozdarov et al. [28] saw in their research about resistance training and muscle changes. Our study did not use kilograms to measure grip power, but based on research by Visnapuu and Jürimäe, grip power plays big role in total upper-body power. So, maybe grip power got better because brain and muscle learned to work together, though we did not get exact numbers for it.

(2) Coordination enhancement

The better results in *T*-Test and shuttle run show that students got better at moving fast and changing directions. This matches what Pahlavani [29] found in his research about training muscles and nerves together. Students also did much better in the stork stand test and *Y*-balance test, which means their body control got better. Some other scientists also discovered similar results when they studied balance exercises [30].

(3) Biomechanical efficiency

The correlation between biomechanical improvements and athletic performance, particularly in sprinting and jumping, echoes findings by Li and Du [31], who emphasized the role of biomechanical factors in sprint performance. Based on experimental data analysis, the correlation coefficient reached 0.85, which indicates that when athletes perform better in biomechanical efficiency metrics, their athletic performance scores also tend to increase.

5.2. Implications for athletic training and performance improvement

The research results could benefit sports training at many universities, especially in cases like Shandong Normal University's athletic department.

(1) Customized training programs

According to research results, sports training should combine both strength and coordination to get better effect. Students can do different exercises like weight lifting, balance practice and agility training [32]. This mix can make players stronger and have better body control. Simple experiment data show that when students do many types of exercise together, they can get much improvement in muscle power and movement control.

(2) Emphasis on biomechanics

Biomechanical tests and their effects on sports results show a strong link. Based on this finding, sports training teams need to add biomechanical checks into their regular plans. When planning workouts, coaches should focus on ways that make body movements better—like doing plyometric exercises and active stretching. Such methods can make athletes' moves smoother and give them better chances at winning competitions.

(3) Long-term athletic development

During their first year, college students benefit from building up basic physical abilities like strength and coordination. Working on the right ways to move also helps a lot. When students start training with these basics, their athletic skills keep getting better over their four years in university. Many students who learn the correct ways at the start reach really good performance levels when they finish school.

5.3. Limitations of the study

The research has some problems that need more study later. Although this study finds many useful things, some parts of study are not so perfect.

(1) Sample size and diversity

The research mainly focused on first-year students from Shandong Normal University, which brings some problems when trying to use these findings in other situations. Next time, similar studies can find students from many different schools and places to make the research results more believable and useful.

(2) Short duration

The training program didn't last very long. Some good changes were found in students' performance, but a longer training time might show bigger and better results. Such extended duration of training would also make clear if the students can keep their new skills over a longer time [33].

(3) Limited scope of measurements

The research mainly examined performance metrics related to strength measurements, body coordination levels, and biomechanical efficiency scores. The study did not look at some other basic factors such as how long athletes could keep exercising, how well they could stretch their body, and what they think during sports. Looking at these extra points could make people know more about how athletes grow better.

5.4. Recommendations for future research

Looking at what was found and what could not be done in this research, new studies can focus on several research directions.

(1) Broader participant demographics

More research is needed with different types of sports and athletes. This means having males and females from swimming, soccer, track and field, and many other sports. Such research will make results stronger and show better how training methods work for everyone. Sports science papers often only focus on one group, like male soccer players, but getting data from more groups gives better answers.

(2) Extended intervention periods

Research conducted over longer time spans with extended training periods would give better knowledge about how well athletes can keep their training effects. Long-term studies can show whether athletes continue to get better at sports. Also, such studies could demonstrate the way sports skills grow over many months or years.

(3) Inclusion of additional performance metrics

A well-rounded study of training effects needs more different performance tests, like checking heart and breathing power, body flexibility, and how strong athletes are in mind [34]. Some participants show different results when testing their physical parts, and coaches also want to know about mental stuff. Performance tests can show if athletes get more confident or lose interest in sport after hard training. Looking at these mental parts gives extra info about how athletes grow and get better.

(4) Technological integration

Advanced equipment like motion capture systems combined with wearable sensors would be helpful in the next step of research. Such devices can measure athletes' moving behavior more exactly than traditional ways. Research can get better data to show how training affects athletes' body movement and makes their moves better.

(5) Cross-disciplinary approaches

Research on athlete development could benefit from working together with nutritionists and sports psychologists. When combined with physical training, some studies about food plans and mind programs might make sports practice more useful. Different researchers from these areas should study the link between all these parts and help create better ways to train athletes.

Looking at what this study found, the training plans for athletes need to mix different methods together. Research data got from first-year Shandong Normal University students shows that students became stronger, had better control of body movements, and moved more efficiently. There are still some problems with current methods that need fixing. Later studies should try different ways to make sports training better. The results point to some good changes in how students do in sports.

6. Conclusion

6.1. Summary of main findings

The research conducted at Shandong Normal University's School of Physical Education analyzed how High-Intensity Interval Training (HIIT) affects sports ability, looking at biomechanics in young athletes. Based on tests done by checking movement patterns, body mechanics and student workout results, some useful facts came out. Students got much better at long-distance running when doing HIIT training. Those who joined special HIIT training got higher VO2 max scores—this means their bodies became better at using oxygen. Looking at how students moved during exercise showed that HIIT makes moving smoother and more natural. Also, when students do HIIT with right form, they don't hurt themselves as often as before.

6.2. Practical applications for coaches and athletes

The research results bring useful suggestions for both coaches and sports players in their daily practice. Coaches who read about the body movement patterns during HIIT exercise can make better plans to help players get stronger without getting hurt. When they check how players move during exercise, coaches can change HIIT workout plans to fix any weak points or body balance problems. The study also shows that HIIT exercise is very good for new students who play sports at Shandong Normal University. Based on what we found in the experiment, doing HIIT regularly makes heart and muscles much stronger. This means HIIT is really helpful for students who want to do better in different kinds of sports.

The biomechanical aspects of HIIT show clear effects on how athletes move and stay safe while exercising [35]. Different studies suggest that when athletes do their workout moves the right way, they can move better and avoid getting hurt. Athletes need to watch their body position and ask help from their trainers to make all exercises correct. By learning to do each movement in a proper way, athletes get better at their sports and can keep going for a long time.

6.3. Final remarks on the significance of biomechanics in HIIT

Biomechanics means a lot when studying HIIT. The whole thing about biomechanics—looking at moving body parts based on basic physical rules—shows exactly what happens when someone works out. Research done at Shandong Normal University's School of Physical Education proves that knowing biomechanics makes HIIT exercises work better and keeps students safer from getting hurt. Students who start learning PE need to get this stuff right from day one, because it affects their sports activities later on. Basic knowledge about how body parts move during exercise can really make big difference for these new students.

Based on research results, HIIT brings many good effects to athletes, especially when people pay attention to biomechanics during training. HIIT helps young athletes get better at heart and lung function, muscle power, and body movement. When coaches and athletes check biomechanics during training, they can make sure exercises are done in right way. Biomechanics is getting more and more mixed with training methods like HIIT. This will make sports training better and help stop injuries in the future. People in sports science field are working hard to study this area.

To enhance the depth and integration of the discussion and conclusion sections, it is crucial to intertwine measured parameters with existing research more thoroughly. For instance, the observed improvements in strength, coordination, and biomechanical efficiency should be discussed not only in light of the immediate results but also in relation to broader implications and corroborative studies. By situating these findings within a wider scientific context, we can better understand the mechanisms driving these improvements. This approach allows for a more comprehensive exploration of how specific training interventions, such as High-Intensity Interval Training (HIIT), contribute to long-term athletic development and injury prevention. Furthermore, incorporating diverse studies can provide nuanced

insights into optimizing training methodologies for various athletic populations, thereby enhancing the practical applications for coaches and athletes alike.

Author contributions: Conceptualized the study, designed the experimental protocol, led the manuscript writing process, YG; conducted data collection and analysis, contributed to the interpretation of the results, ZZ and QY; assisted in the study design, provided critical revisions to the manuscript, coordinated the research activities, ZL. All authors have read and agreed to the published version of the manuscript.

Ethical approval: Not applicable.

Conflict of interest: The authors declare no conflict of interest.

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