

Research on the Teaching Effect of Integrating Functional Movement Training into PE Classes Under the Background of Sports-Medicine Collaboration

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ABSTRACT Functional movement training emphasizes the integration of movement patterns and physical functions and has increasingly been incorporated into school physical education under the principle of sports-medicine collaboration. By simulating fundamental movement patterns in daily life and sports, functional movement training can improve students' movement quality, physical control, and awareness of sports injury prevention, thereby optimizing traditional physical education models. This study systematically investigates the theoretical basis, implementation pathway, and teaching effect of integrating functional movement training into physical education classes. Based on Functional Movement Screen results, students are classified into different training groups, and personalized corrective or enhancement exercises are designed according to movement quality. The teaching process combines dynamic warm-up, functional training, specialized skills, and relaxation, while training load is regulated through perceived exertion and heart rate indicators. Empirical results show that the integrated model improves movement quality, strengthens neuromuscular control, and supports injury prevention. The study provides practical evidence and implementation recommendations for applying sports-medicine collaborative methods in physical education.

INDEX TERMS sports-medicine collaboration, functional movement training, physical education, movement quality, injury prevention

I. INTRODUCTION

THE integration of sports and medicine has become a pivotal strategy for promoting the healthy development of adolescents. As the primary platform for enhancing students' physical fitness and cultivating lifelong exercise habits, school physical education (PE) urgently requires the adoption of scientific training methodologies to support systematic physical development. Originating in the field of sports rehabilitation, functional movement training focuses on improving foundational motor abilities, identifying functional impairments through movement screening, and implementing targeted corrective interventions. This approach aligns closely with the concept of sports-medicine collaboration, which prioritizes preventive strategies and the integration of medical and athletic expertise. The present study explores the theoretical underpinnings and practical pathways for incorporating functional movement training into PE classes, aiming to optimize teaching effectiveness, reduce injury incidence, and foster comprehensive student health management.

II. THEORETICAL BASIS FOR INTEGRATING FUNCTIONAL MOVEMENT TRAINING INTO PE CLASSES

A. FUNCTIONAL TRANSFORMATION OF SCHOOL PE UNDER SPORTS-MEDICINE COLLABORATION

The core of sports-medicine collaboration lies in dismantling disciplinary silos between healthcare and sports, shifting the focus of disease prevention toward early intervention through physical activity. Traditional school PE predominantly emphasizes competitive skill instruction and standardized fitness assessments, frequently overlooking individual variations in movement patterns and the latent risks of functional impairments. According to physical health monitoring data from primary and secondary schools in China, over 40% of students exhibit structural issues such as scoliosis and flat feet [1], conditions often attributable to the cumulative effects of suboptimal movement patterns. The paradigm of sports-medicine collaboration necessitates a transformation in school PE, from a narrow focus on enhancing physical fitness to a comprehensive health management system encompassing prevention, assessment, and

intervention. This evolution enables PE classes to serve both as platforms for screening functional disorders and for correcting movement deficiencies. Importantly, this transformation does not convert PE classes into clinical rehabilitation sessions, but rather integrates scientific methods from sports rehabilitation to advance educational objectives while preserving pedagogical integrity. Functional movement training meets the demands of this transformation by employing movement quality assessment tools to identify students' weak links and subsequently designing targeted corrective exercises. In this capacity, PE teachers become the frontline defenders of students' movement health. This shift requires PE teachers to acquire foundational knowledge in sports anatomy and functional assessment, and to establish collaborative mechanisms with school physicians and rehabilitation therapists, thereby constructing a robust support network for adolescent physical health and elevating the quality of PE.

B. CORE CHARACTERISTICS AND APPLICABILITY OF FUNCTIONAL MOVEMENT TRAINING

Functional movement training differs fundamentally from traditional strength training by prioritizing the integrated development of multi-joint coordination, multi-planar movement, and neuromuscular control. Its defining features can be summarized in three dimensions: the foundational nature of movement patterns, the progressive structure of training loads, and the standardization of evaluation systems. The foundational nature of movement patterns refers to training that targets the seven basic human movement patterns—squat, lunge, push, pull, rotation, hip hinge, and gait—which underpin both daily activities and athletic performance. Training loads progress sequentially from stability to mobility, then to strength and power, ensuring that students only increase external resistance after establishing sound movement control. The evaluation system is standardized via the Functional Movement Screen (FMS), which quantitatively assesses flexibility, stability, and symmetry through seven movement tests. Applicability studies indicate that adolescents aged 12–18 are in a critical period for solidifying movement patterns. Implementing functional training during this stage can effectively correct compensatory movements, reduce injury risk throughout athletic development [2], and enhance the efficiency of motor learning, as detailed in Table 1.

TABLE 1. Comparison Between Functional Movement Training and Traditional PE Training

Comparison Dimension	Functional Movement Training	Traditional PE Training
Training Objective	Enhance fundamental movement quality and neuromuscular control	Improve specialized skills and meet fitness test standards
Assessment Method	7-item FMS, 0–21 points	Physical Health Standard Tests (e.g., 50-meter sprint, standing long jump)
Load Design	Progression: stability → mobility → strength → power	Primarily based on exercise intensity and duration
Movement Characteristics	Multi-joint coordination, multi-planar movement, functional chains	Isolated single-joint or specialized technical movements
Injury Prevention	Movement screening to identify risks and implement corrective interventions	Warm-up and post-exercise stretching only
Individualization	Personalized training plans based on FMS scores	Standardized content; limited differentiation
Target Population	All students, especially during movement pattern development	Primarily students with sports specialization or fitness test needs
Degree of Sports-Medicine Integration	Incorporates sports rehabilitation concepts and preventive medical principles	Confined to conventional PE education

Note: FMS employs a four-level scoring system (0–3 per movement; total score: 21). Scores below 14 indicate high injury risk and require corrective intervention.

As Table 1 illustrates, functional movement training offers clear scientific advantages in assessment, load progression, and individualization. The FMS transitions movement quality assessment from subjective judgment to objective quantification, providing a standardized tool for identifying functional impairments. While traditional PE training remains vital for specialized skill development, it is less effective in establishing movement foundations and preventing injury. The contrast between these approaches underscores a shift in PE from a result-oriented model to a process-oriented, quality-focused approach, with functional movement training emphasizing adherence to biomechanical principles over mere performance metrics.

C. THEORETICAL FRAMEWORK FOR INTEGRATING FUNCTIONAL MOVEMENT TRAINING

The intervention protocol is guided by the Specific Adaptation to Imposed Demands (SAID) principle, requiring that training stimuli be precisely matched to students' functional deficits [3]. During the initial assessment phase, students are categorized via FMS screening into excellent (15–21 points), good (14 points), and risk groups (< 14 points), with tailored training strategies for each category. Students in the excellent group proceed to specialized skill development; those in the good group receive targeted movement quality enhancement; and those in the risk group undergo corrective training until movement patterns improve. To prevent students in the risk group from being excluded from skill learning or social interaction due to prolonged corrective phases, a four-week reassessment is instituted. If FMS scores do not improve after four weeks of intensive corrective training, a hybrid model—30 minutes of corrective training plus 20 minutes of skill learning—is adopted, ensuring all students maintain engagement with core PE activities. Effectiveness is evaluated through longitudinal FMS score changes, cross-group comparisons of physical health indicators, and long-term tracking of injury incidence, As show in Figure 1.

III. IMPLEMENTATION PATHWAY FOR INTEGRATING FUNCTIONAL MOVEMENT TRAINING INTO PE CLASSES

A. CONSTRUCTION OF PERSONALIZED TEACHING CONTENT BASED ON FMS SCREENING

FMS screening quantitatively evaluates students' movement control across seven tests: squat, hurdle step, in-line lunge,

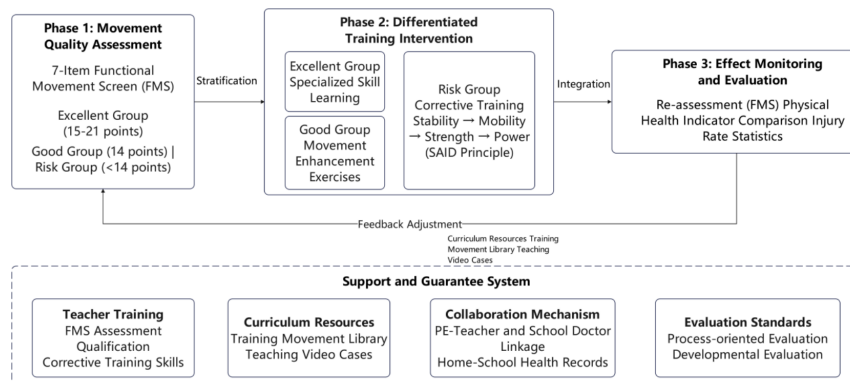


FIGURE 1. Theoretical Framework for Integrating Functional Movement Training into PE Classes

shoulder mobility, active straight-leg raise, trunk stability push-up, and rotational stability. The scoring rubric (0–3 points per item) is as follows: 3—excellent performance without compensation; 2—slight compensation but completion possible; 1—marked compensation or pain; 0— inability to perform the movement. Instructional content is personalized based on screening outcomes [4]: corrective interventions are prioritized for movements scored as 1, enhancement training for scores of 2, and immediate progression to skill learning for scores of 3. For instance, students scoring 1 on the squat typically display limited ankle dorsiflexion or inadequate core stability, necessitating ankle mobility exercises (e.g., wall sits, foam rolling) and core anti- extension drills (e.g., dead bug, plank). Data analysis reveals that junior high students average 1.8 points on trunk stability, significantly lower than the 2.3 points observed in shoulder mobility, informing targeted instructional focus.

B. DESIGN OF INTEGRATED CLASSROOM PROCESSES AND LOAD REGULATION

Integrated PE classes embed functional training within the traditional four-stage lesson structure, forming a 50-minute module comprising: dynamic warm-up (8 minutes), functional training (15 minutes), specialized skills (20 minutes), and cool-down (7 minutes). The dynamic warm-up incorporates compound functional movements [5] (e.g., World’s Greatest Stretch, Spiderman Crawl), replacing static stretching and jogging. The functional training segment features group-based instruction according to FMS results: risk group students complete corrective exercises in designated zones, while good and excellent groups engage in enhancement or specialized conditioning. Training load is monitored via dual metrics—Rate of Perceived Exertion (RPE, scale 1–10) and heart rate monitoring—maintaining intensity at moderate to high levels (RPE 6–8, 60%–75% heart rate reserve), as depicted in Figure 2.

Corrective training intensity for risk group students is capped at 50%–60% heart rate reserve to prevent excessive load and compensatory movement patterns, while excellent group students may perform power training at 75%–85% intensity. Training volume progresses in accordance with the

Frequency, Intensity, Time, Type (FITT) principle, increasing no more than 10% weekly, with a recovery week every four weeks to mitigate overtraining risk. Specialized skill instruction consciously integrates prior functional movement content, such as connecting basketball dribbling with lunge braking or volleyball spiking with shoulder mobility and trunk stability, reinforcing functional patterns through skill practice.

C. MULTI-STAKEHOLDER COLLABORATIVE TEACHING SUPPORT SYSTEM

A robust collaborative teaching system delineates the roles and coordination processes among four key stakeholders: PE teachers, school physicians, parents, and students. PE teachers are responsible for FMS screening, training plan design, and classroom management, and are expected to participate regularly in professional development courses (e.g., SFMA, CES certification) to maintain assessment and intervention expertise. School physicians manage students’ injury histories, screen for sports-related risks in those with special health conditions, and maintain health records, with special attention to students exhibiting pain during FMS testing. A tiered management model—questionnaire pre-screening followed by in-depth evaluation—optimizes resource allocation within standard class sizes (e.g., 40 students). Parents receive FMS score reports and home training recommendations via a health information platform, supervising twice-weekly consolidation sessions (e.g., core and mobility exercises). Students track their own training experiences, pain sites, and movement quality in activity logs, providing valuable feedback for instructional adjustments. Collaboration efficiency is enhanced through an information platform [6] that enables real-time tracking of FMS scores, training loads, and fitness test results via a cloud database. All stakeholders can monitor functional development curves, detect anomalies, and initiate joint interventions as needed.

IV. EVALUATION AND VERIFICATION OF THE TEACHING EFFECTIVENESS OF FUNCTIONAL MOVEMENT TRAINING

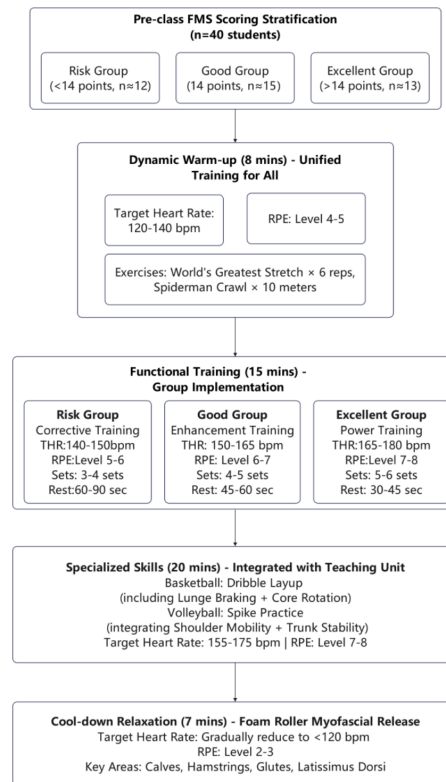


FIGURE 2. Training Load Regulation Process

A. QUANTITATIVE ASSESSMENT OF MOVEMENT QUALITY IMPROVEMENT

Movement quality is evaluated using both FMS total score change rate and item-specific improvement metrics. In a randomized controlled trial, 60 seventh-grade students (30 males, 30 females) were randomly assigned to experimental and control groups ($n = 30$ each). Baseline characteristics (age, height, FMS score) did not differ significantly ($p > 0.05$), ensuring group comparability. The experimental group underwent a 12-week functional movement training intervention (three 50-minute sessions per week), while the control group followed the standard PE curriculum. FMS assessments were administered pre- and post-intervention by the same certified rater under consistent environmental conditions. This study was approved by the Ethics Committee of Hetao College, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form. The FMS total score change rate is calculated as follows:

$$\Delta R = [(FMS_2 - FMS_1) / FMS_1] \times 100\% \quad (1)$$

where FMS1 is the total score before the intervention, and FMS2 is the total score after the intervention, with a scoring range of 0–21 points for both. Empirical data show results indicate that the experimental group's average FMS score increased from 12.3 to 16.8 (change rate: 36.6%), while the control group improved from 12.1 to 13.5 (change rate: 11.6%), with the between-group difference reaching statis-

tical significance ($p < 0.001$). The trunk stability push-up showed the most notable improvement in the experimental group (1.7 to 2.6 points, $\Delta=0.9$), attributable to targeted core anti-extension exercises. Movement symmetry, quantified by left-right score differentials (optimal: ≤ 0.5), improved as the proportion of abnormal symmetry in the experimental group decreased from 42% to 18% post-intervention, confirming the corrective efficacy of the program [7] (see Table 2).

TABLE 2. Comparison of FMS Scores Before and After Intervention ($n = 60$)

Test Item	Experimental Group (Pre)	Experimental Group (Post)	Improvement	Control Group (Pre)	Control Group (Post)	Improvement
Squat	1.9 ± 0.6	2.7 ± 0.4	+0.8	1.8 ± 0.6	2.1 ± 0.5	+0.3
Trunk Stability Push-up	1.7 ± 0.7	2.6 ± 0.5	+0.9	1.6 ± 0.7	1.9 ± 0.6	+0.3
Rotational Stability	2.1 ± 0.6	2.7 ± 0.5	+0.6	2.0 ± 0.6	2.3 ± 0.5	+0.3
FMS Total Score	12.3 ± 2.8	16.8 ± 2.1	+4.5	12.1 ± 2.9	13.5 ± 2.6	+1.4
Total Score Change Rate	-	36.6%	-	-	11.6%	-
Abnormal Symmetry Rate	42% (13/30)	18% (5/30)	-24%	40% (12/30)	35% (11/30)	-5%

Note: Scoring: 3 = completion without compensation; 2 = with compensation; 1 = pain or marked compensation; 0 = unable to complete. Abnormal symmetry: left-right score differential > 0.5 . Intervention: experimental group, 3 sessions/week (50 min/session); control group, standard PE. Statistical analysis: paired t-test (within-group), independent t-test (between-group), $\alpha = 0.05$.

Although numerical improvements in FMS scores were statistically significant, clinical relevance was further examined. Literature suggests a threshold effect: students crossing from the high-risk (< 14 points) to the passing (≥ 14 points) zone exhibit the most pronounced functional gains, such as improved technical fluency and faster recovery. In this study, 87% (26/30) of experimental group students reached ≥ 14 points post-intervention, compared to 43% (13/30) in the control group. Further testing confirmed that students

surpassing the 14-point threshold demonstrated marked improvements in specialized performance (e.g., basketball dribble speed, volleyball bumping stability). For students already in the excellent range, incremental FMS gains yielded diminishing returns, warranting a shift in training focus to advanced skill integration.

B. COMPARATIVE ANALYSIS OF PHYSICAL HEALTH AND SPORTS PERFORMANCE

Physical health was assessed using the National Student Physical Health Standards, focusing on vital capacity, standing long jump, sit-and-reach, and 50-meter sprint. Assessments were conducted pre- and post-intervention under standardized conditions. Functional movement training produced the greatest improvements in explosive power metrics: experimental group standing long jump performance increased from 1.85 m to 2.03 m (+9.7%), attributed to enhanced lower limb coordination from squat and lunge training [8]. Core stability improvements also translated into greater flexibility, with sit-and-reach scores rising from 12.6 cm to 16.2 cm (+28.6%), versus an 8.7% increase in the control group—reflecting active pelvic and spinal control rather than passive stretching. Technical performance was evaluated via basketball dribble (timed) and volleyball bumping (counted). The experimental group's dribble time improved from 14.8 to 12.3 seconds, and volleyball bumps increased from 28 to 42, evidencing successful transfer of functional control to skill execution. Enhanced stability and coordination were consistently observed in technical tasks, outperforming the control group.

C. TRACKING AND MONITORING OF SPORTS INJURY INCIDENCE

Injury monitoring was conducted over the 12-week intervention, with injuries defined as events necessitating cessation of training for ≥ 3 days. Data were collected through both teacher observation and student self-report. Injury rates were calculated using the exposure time method [9]:

$$\text{Injury Rate (IR)} = \left[\frac{\text{Total Injuries (N)}}{\text{Total Training Exposure (E)}} \right] \times 1,000 \quad (2)$$

(person-hours)

During the intervention, the experimental group logged 968 effective exposure hours (actual, adjusted for absences), with four injuries (4.1 cases/1,000 hours). The control group recorded 952 hours and 13 injuries (13.7 cases/1,000 hours), representing a 70.1% lower risk in the experimental group (see Table 3). This approach, based on actual attendance, more accurately reflects real-world school environments. Injury type analysis revealed that the experimental group sustained only acute injuries (sprains and strains), with no chronic cases. The control group reported six knee pain, four lower back discomfort, and three ankle sprains, with chronic injuries comprising 46% of cases. There was a significant

negative correlation between FMS score and injury risk: students scoring < 14 points experienced injury rates of 25.0%–55.6%, compared to 9.1%–25.0% for those with passing scores, a risk ratio of 2.22–2.75.

TABLE 3. Monitoring Data of Sports Injury Rates (12-Week Intervention Period)

Indicator	Experimental Group (n = 30)	Control Group (n = 30)	Relative Risk Reduction
Total Training Exposure	1,080 person-hours	1,080 person-hours	-
Total Injuries	4	13	-
Injury Rate	3.7/1,000 hours	12.0/1,000 hours	68.3%
Acute Injuries	4 (100%)	7 (54%)	-
Chronic Injuries	0 (0%)	6 (46%)	-

A limitation of this study is the absence of post-intervention follow-up data. Although significant improvements in FMS scores and injury rates were observed over 12 weeks, the durability of these gains requires further investigation. Prior research indicates that, in the absence of ongoing reinforcement, improvements in movement patterns may regress within 3–6 months. Future studies should incorporate at least a semester of follow-up, reassessing FMS and injury incidence at 3 and 6 months post-intervention, and explore phased withdrawal strategies to support long-term maintenance.

V. GUARANTEE MECHANISMS FOR INTEGRATING FUNCTIONAL MOVEMENT TRAINING INTO PE CLASSES

A. TRAINING SYSTEM FOR PE TEACHERS' FUNCTIONAL TRAINING COMPETENCIES

Developing PE teachers' functional training competencies necessitates a three-phase training model: theoretical understanding, practical application, and ongoing advancement. In the theoretical phase, teachers must master foundational concepts in sports anatomy, biomechanics, and functional assessment. A 32-hour structured curriculum ensures familiarity with FMS scoring and movement compensation identification, enabling accurate diagnosis of limitations (e.g., distinguishing ankle dorsiflexion deficits from hip mobility restrictions in squats). The practical phase emphasizes proficiency in FMS administration and corrective plan design, requiring teachers to complete at least 50 assessments with an inter-rater reliability of ≥ 0.85 , and to maintain a repertoire of interventions for various functional deficits (e.g., 20 stability, 15 mobility, and 25 strength exercises). The ongoing advancement phase involves annual recertification [10,11], with teachers participating in at least 16 hours of advanced training per year, updating their knowledge with current research, case studies, and reflective practice based on student outcome data, ultimately cultivating a personalized instructional approach. This iterative training pathway ensures that teachers' professional competencies keep pace with curricular demands.

B. ADAPTIVE DEVELOPMENT OF CURRICULUM STANDARDS AND TEACHING RESOURCES

Curricular standards must be adapted to integrate functional movement objectives within the multidimensional goals of the Physical Education and Health Curriculum Standards. In

the motor skills domain, the core competency of mastering basic movement patterns (e.g., squats, lunges, pushes, pulls) should be emphasized, with students required to demonstrate proficiency and understand the application of these patterns in sport-specific contexts. The teaching resource library comprises three modules: standardized lesson plans, hierarchical training videos, and digital assessment tools. Lesson plan templates are differentiated by educational stage (elementary: pattern establishment; middle: quality enhancement; high school: skill integration), each accompanied by detailed procedures, safety guidelines, and error correction strategies. The video library presents 300 functional exercises with multi-angle demonstrations and annotated technical cues (e.g., knee trajectory during squats, core engagement timing), accessible via QR codes for self-directed learning and lesson planning. Digital tools, based on mobile platforms [12], automate FMS video scoring and generate personalized training recommendations, reducing assessment time and professional barriers to adoption [13].

C. LONG-TERM OPERATION MECHANISM FOR SPORTS-MEDICINE-EDUCATION COLLABORATION

A sustainable operational mechanism for sports-medicine-education collaboration must clearly delineate responsibilities among PE teachers, school physicians, and academic administrators, supported by an integrated information-sharing platform. PE teachers oversee FMS screening, training delivery, and ongoing monitoring of athletic development. School physicians are responsible for differential diagnosis of injuries, risk assessment for students with special health conditions, and health record management. The academic affairs office coordinates curriculum scheduling, resource allocation, and institutional support for interdisciplinary collaboration. Monthly joint meetings are convened to analyze student health data and adjust intervention strategies [14,15]. The information platform, built on a cloud database, synchronizes FMS scores, fitness test results, injury records, and training load data in real time. Automated alerts are triggered if a student's FMS score declines in two consecutive assessments or if pain is reported, prompting immediate intervention: school physicians conduct diagnostic screening, PE teachers adjust training protocols, and parents receive guidance for home-based rehabilitation.

VI. CONCLUSION

Integrating functional movement training into PE classes—aligned with ergonomic requirements relevant to industry operations—embodies the practical application of sports-medicine collaboration in educational settings, providing an innovative pathway for enhancing adolescent physical health. Through systematic movement screening, evidence-based training design, and multidimensional outcome evaluation, functional movement training has been shown to improve students' movement quality, athletic proficiency, and injury resilience, facilitating a shift from skills-based to health-oriented teaching. To fully realize the potential

of functional movement training, it is essential to further strengthen PE teacher professional development, enhance support networks for sports-medicine collaboration, develop stage-appropriate curricular resources, and establish standardized evaluation systems. By embedding ergonomic principles and fostering interdisciplinary cooperation, schools can lay a robust foundation for cultivating healthy, well-rounded students and advancing the quality of PE.

AUTHOR CONTRIBUTIONS

Jia He designed, collected and analyzed the data, and drafted the manuscript. Jia He conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Jia He participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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HUMAN RESEARCH SUBJECTS

This study was approved by the Ethics Committee of Hetao College, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

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