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Effects of blended learning in physical education on university students' exercise attitudes and basketball skills: a cluster randomized controlled trial

Chen Wang[2], Yubin Yuan[1*] and Xueyan Ji[1]

Abstract

Background The importance of physical education in higher education is widely recognized, as it improves not only exercise attitudes and motor skills but also physical fitness, social skills, and academic performance. However, physical education courses in Chinese colleges and universities face various constraints, such as a shortage of teachers, limited teaching methods, and insufficient resources, resulting in low student motor skills, negative attitudes toward sports, and low participation rates. This study explores the effectiveness of a blended learning model, which integrates traditional face-to-face instruction with online learning components, in improving university students' exercise attitudes and basketball skills.

Methods The research was conducted in 2022 at Luoyang Normal University in China, utilizing a cluster randomized controlled trial (CRCT) with 78 healthy first-year university students. Participants were randomly assigned to either the experimental group (blended learning) or the control group (traditional learning), and the intervention lasted 16 weeks. Exercise attitudes were assessed via the Exercise Attitude Scale, whereas basketball skills were evaluated via set shot and half-court dribbling and shooting tests.

Results Both instructional models improved students' exercise attitudes and basketball skills; however, the blended learning model demonstrated significantly superior outcomes. Effect sizes (d) ranging from 0.57 to 1.92 indicated that the experimental group showed greater improvements in behavior attitude, target attitude, behavior cognition, behavior intention, emotional experience, behavior control, and subjective standards. In basketball skills, the experimental group outperformed the control group in set shots (d = 0.56) and half-court dribbling and shooting (d = 0.46).

Conclusion Compared with traditional methods, blended learning significantly enhances university students' exercise attitudes and basketball skills. Future research should explore the long-term effects and underlying mechanisms of blended learning in physical education, involving larger and more diverse samples to validate these findings.

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Keywords Blended learning, Exercise attitude, Basketball skills, Physical education, Higher education

Introduction

The importance of physical education in higher education is recognized internationally [1, 2]. Research indicates that, in addition to enhancing exercise attitudes and motor skills, high-quality physical education courses positively influence students in areas such as physical fitness, social skills, emotional management (e.g., stress reduction), and social responsibility (e.g., teamwork and community involvement) [3–5]. However, physical education programs in many Chinese colleges and universities are limited by an insufficient number of qualified teachers, a lack of diversified teaching resources, and a reliance on traditional single-teaching methods, which hinder the overall effectiveness of physical education teaching and lead to low levels of students' motor skills, negative attitudes, and insufficient participation in sports [6–8]. These issues negatively affect students' physical and mental health and academic performance and may even impact their long-term quality of life [9, 10]. In response to these common issues in physical education, educators are seeking more effective and flexible instructional models to provide novel learning experiences, improve learning outcomes, and enhance students' attitudes toward exercise and motor skills.

Advanced internet technologies, such as learning management systems (LMSs), online video platforms, and interactive digital tools, have created new opportunities for teaching and learning in higher education, facilitating the development of blended learning models [11–13]. Blended learning, an emerging learner-centered educational model that combines internet-based online learning with traditional classroom instruction, has received increasing attention in the field of education in recent years [14, 15]. It uses time and space flexibility, resource sharing, and timely feedback from online learning to address the shortcomings of traditional classroom instruction [16]. Research has shown that transitioning from traditional instruction to learner-centered blended learning can help students develop higher levels of cognitive processes and improve their ability to acquire and apply knowledge [17] and that this transition leads to richer learning experiences and better learning outcomes [18].

In recent years, many colleges and universities in China have successfully integrated blended learning into courses [19, 20]. However, existing research on blended learning has focused mainly on subjects such as English [21], computer science [22]; accounting [23], and mathematics [24]. Empirical evidence on the effects of blended learning in physical education courses, especially on university students' exercise attitudes and motor skills, remains limited. Although a limited number of domestic and international studies have explored the effects of blended learning on other sports (e.g., dance, badminton, and volleyball), the results have been inconsistent [25–27], with most studies focusing on improving teamwork skills or performance in specific sports. In contrast, basketball is one of the most popular sports among Chinese college students [28], making it an ideal focus for this study due to its wide participation and strong appeal. Compared to other sports, basketball may exhibit different teaching and learning outcomes in a blended learning model, particularly because of its widespread participation and unique technical and tactical demands in Chinese colleges and universities. Therefore, this study aimed to investigate the effects of blended learning on university students' exercise attitudes and basketball skills at Luoyang Normal University in China.

Materials and methods

Participants

The study employed a cluster randomized controlled trial (CRCT) design. The sample size was calculated via G-Power 3.1 software [29]. The effect size was identified based on previous studies that reported an effect size of 0.20 for similar interventions [30]. Considering a type I error (α)=0.05 and a power value (1 - β)=0.80, the total sample size should be 52, with 26 samples in each group. According to Donner, Birkett, and Buck (1981), the CRCT design enhances the study's internal validity by considering design effects to assess intervention effects more accurately [31]. Considering the design effect of cluster randomization and an expected dropout rate of 20%, based on similar previous studies, the sample size for this study was adjusted to 78, with 39 individuals in each group."

The study was approved by the Ethics Committee of Universiti Putra Malaysia (approval number: JKEUPM 2022–030). The research was conducted in 2022 at Luoyang Normal University in China. Two public basketball classes were selected and randomly assigned to the experimental and control groups. The study included healthy first-year university students without joint injuries or other impairments. Participants were excluded if they had systematically taken basketball courses, participated in basketball training, habitually played basketball in their spare time, took supplements daily, or withdrew from the experiment due to uncertainty. Figure 1 summarizes the sampling procedure. In the final analysis, 34 students in the experimental group and 35 students in the control group were included.

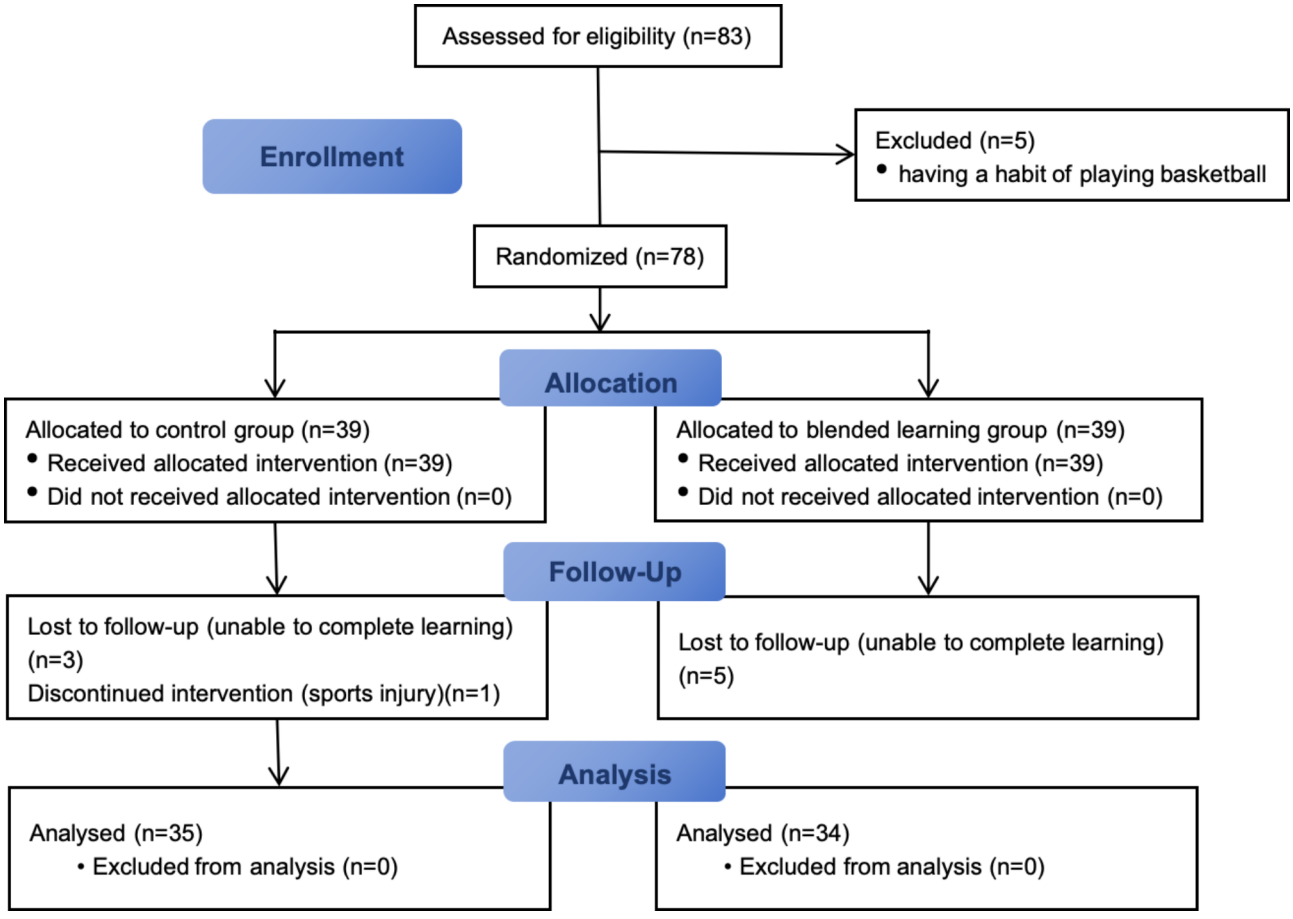

Fig. 1 Participants' flow diagram

Table 1 Basketball teaching implementation

		Control group	Experimental group
Preclass	5–10 min	• Preview the new learning content	• Watching online videos independently • Online assignments/discussion
During-class	Preparation Section (20 min)	• Procedures (Check Attendance/Learning content and goals/Learning requirements) • Warm Up	• Procedures (Check Attendance/Learning content and goals/Learning requirements) • Warm Up
	Basic Section (60 min)	• Review previous learning content • Explaining and demonstrating new basketball skills • Individual/group exercises • Physical Fitness/Teaching Competition	• Review previous learning content • Explaining and demonstrating new basketball skills (Focus on explaining doubts and difficulties) • Individual/group exercises • Physical Fitness/Teaching Competition
	Conclusion Section (10 min)	• Cool down • Class Summary	• Cool down • Class Summary
After-class	1–3 min	• Review the learning content	• Reflection and summary • Online test

Intervention

Two basketball classes were randomly assigned to the experimental and control groups, with the experimental group using a blended learning model and the control group using a traditional learning model. The experimental and control groups were taught public basketball courses on Mondays and Tuesdays from 10 a.m. to 11:30 a.m., respectively, for 16 weeks.

The blended learning model was divided into three parts: before, during, and after class (refer to Table 1). Both the before-class and after-class components were completed on the MOOC platform. The online course used in this study was titled *Basketball Basic Techniques*, taught by Prof. Sunan Li and Assoc. Prof. Ti Hu from Beijing Normal University. This course is aligned with the traditional Chinese basketball syllabus, covering

fundamental basketball skills and techniques. Before class, the teacher assigned learning tasks on the MOOC platform according to the syllabus and teaching requirements of the public basketball course. Students independently preview course videos according to their own schedules and learning pace. During class, the experimental group and the control group had the same teaching content and methods. The difference is that the students in the experimental group had previewed the new content before class, so the teacher paid more attention to the explanations and demonstrations of the key points and difficulties in the classroom and left more time to organize the students to practice and correct the technical movements. Through repetition and constant correction, students can develop a deeper understanding of motor skills and concepts, leading to enhanced cognitive and motor skills and improved athleticism [32, 33]. Furthermore, the teacher answers questions raised by the students and provides suggestions for improvement in the class. After class, the students completed online tests on the MOOC. In addition, the experimental group established a WeChat group to facilitate instant interaction between teachers and students and to share learning and practice experiences.

The control group adopted the traditional basketball teaching method, and the teacher had no other mandatory requirements except for encouraging students to preview and review independently. Basketball teaching was conducted in three stages: the preparation section, the basic section, and the conclusion section. During the preparation section, warm-up activities were conducted to prevent sports injuries. The basic section is the core of teaching. The teacher first leads students to review previous learning content and then explains and demonstrates in detail the new basic movements and requirements of basketball, such as dribbling, passing, shooting, and defensive skills. Students practice in groups to increase interaction and collaboration, whereas the teacher provides individual instruction and corrections to a few students. Physical fitness training or teaching competitions will also be arranged according to the syllabus. In the conclusion section, the teacher leads students in relaxation exercises and reviews and summarizes the lesson's content to help reinforce their knowledge.

To avoid the influence of extraneous variables and ensure scientific rigor and objectivity, the experimental and control groups maintained the same conditions, including the same class duration, basketball courts, teaching content, and teachers, with the only difference being the teaching methods used (see Table 2). Online learning logs and attendance records were used to monitor basketball learning and training during the 16-week program. To ensure rigor, the following controls were implemented: first, all participants signed an informed consent form before the experiment, and all participants received the same infrastructure and equipment support throughout the study. Second, to ensure instructional quality and consistency, the same senior basketball coach was responsible for all the instructional activities. Additionally, to avoid subjective bias, teaching effectiveness was assessed by another senior basketball expert via a double-blind method to ensure the fairness of the assessment results.

Evaluation

This study uses the Exercise Attitude Scale and Basketball Skills Test to assess students' exercise attitudes and basketball skills. The Exercise Attitude Scale was developed by Mao Rongjian in 2003 and has been widely used in Chinese universities to assess students' attitudes toward exercise. Students' exercise attitudes were evaluated before the intervention and at the end of week 16. Exercise attitudes were measured via a 5-point Likert scale, where higher scores indicate a more positive attitude. The scale consists of 70 questions and includes eight dimensions: behavior attitude, target attitude, behavior cognition, behavior habit, behavior intention, emotional experience, behavior control, and subjective standards [34]. The scale demonstrated high test-retest reliability, with the following correlation coefficients: behavior attitude (0.83), target attitude (0.87), behavior cognition (0.73), behavior habit (0.89), behavior intention (0.84), emotional experience (0.86), behavior control (0.80), and subjective standards (0.64).

The basketball skill assessment includes set shots (ten times) and half-court dribbling and shooting, which are widely used in college basketball skill tests in China. The set-shot test is conducted as follows: A male student stands at the free-throw line (point A) and takes ten shots; a female student stands one meter away from the free-throw line (point B) and takes ten shots (see Fig. 2). The referee records the student's number of shots made and technical scores. Half-court dribbling and shooting (see Fig. 3) are performed below: A student stands at point A with the ball and faces the basket. Once the referee starts the timer, the student will dribble the ball with the right hand to B and shoot. After the ball shoots the basket, it dribbles to point C; then, it switches to the left hand to dribble from points C to B and shoot. After shooting the basket, the student dribbles back to point A. The timer stops when the student returns to point A. Each student has two opportunities; the referee records the highest and technical scores. Six experts familiar with physical education and exercise training evaluated the basketball skills test, and the results showed excellent content validity (I-CVI = 0.833–1.000, Kappa = 0.816–1.000).

Table 2 Basketball teaching plan

Week	Teaching content	Teaching methods	
		TL	BL
1	Basketball Basic Knowledge, Preparation Stance, Stationary Ball Drills	Explanation Demonstration	Online Video Explanation Demonstration Online test
2	Review previous lesson content Offensive Movement Techniques (Basic stance, Starting techniques, Quick stop techniques) Physical Fitness (jogging/sprint/push-up 10 reps x 2 sets)	Explanation Demonstration	Online Video Explanation Demonstration Online test
3	Review previous lesson content Defensive Movement Techniques (lateral step, retreat step) Physical Fitness (vertical jump 20 reps x2 sets, push-up 10 reps x2 sets)	Explanation Demonstration	Online Video Explanation Demonstration Online test
4	Review previous lesson content One-handed Chest Pass, Two-handed Chest Pass Physical Fitness (Squat 15 reps x2 sets, Push-ups 15 reps x2 sets)	Explanation Demonstration	Online Video Explanation Demonstration Online test
5	Review previous lesson content Stationary Dribbling, Dribbling Physical Fitness (frog jump 15mx2 sets, sprint x2 sets)	Explanation Demonstration Group exercises	Online Video Explanation Demonstration Group exercises Online test
6	Review previous lesson content Standing One-handed Shoulder Shot(Chest Pass for female) Physical Fitness (vertical jump 20 reps x2 sets, push-up 10 reps x2 sets)	Explanation Demonstration Group exercises	Online Video Explanation Demonstration Group exercises Online test
7	Review Dribbling Review Two-handed Chest Pass Review Standing One-handed Shoulder Shot(Chest Pass for female) Physical Fitness (half-court shuttle run x2 sets, full-court sprints x2 sets)	Explanation Demonstration Group exercises	Online Video Explanation Demonstration Group exercises Online test
8	Review previous lesson content Running One-handed Underhand Layup Physical Fitness (Four-lane round trip x2 sets)	Explanation Demonstration Group exercises	Online Video Explanation Demonstration Group exercises Online test
9	Review Standing One-handed Shoulder Shot(Chest Pass for female) Review Running One-handed Underhand Layup Physical Fitness (Push-ups 15 reps x3 sets, Jumping Jacks 15 reps x3 sets) Teaching competition (half-court 3V3 or 4V4)	Explanation Demonstration Group exercises	Online Video Explanation Demonstration Group exercises Online test
10	Review Running One-handed Underhand Layup One-handed Expert Shooting on the Move Physical Fitness (4*10 m round trip x3 sets)	Explanation Demonstration Group exercises	Online Video Explanation Demonstration Group exercises Online test
11	Review Running One-handed Underhand Layup and One-handed Expert Shooting on the Move PF (1-min jump rope x5 sets) Teaching competition (half-court 3V3 or 4V4)	Explanation Demonstration Group exercises	Online Video Explanation Demonstration Group exercises Online test
12	Review previous lesson content Stationary Dribbling Techniques (crossover step, layup), dribbling technique in transition Physical Fitness (Squat 15 reps x2 sets, Push-ups 15 reps x2 sets)	Explanation Demonstration Group exercises	Online Video Explanation Demonstration Group exercises Online test
13	Review Running One-handed Underhand Layup and One-handed Expert Shooting on the Move Review Basketball Breakthrough Techniques Physical Fitness (1-min jump rope x5 sets)	Explanation Demonstration Group exercises	Online Video Explanation Demonstration Group exercises Online test
14	Review previous lesson content Half-court Dribbling and Shooting, Rebounding Techniques Physical Fitness (half-court shuttle run x2 sets, full-court sprints x2 sets)	Explanation Demonstration Group exercises	Online Video Explanation Demonstration Group exercises Online test
15	Revise for the Test		
16	Basketball Skills Test		

Statistics

In this study, all survey and experimental data were collected during the experiment and then analyzed via SPSS (version 26, IBM Company, USA). The significance level was evaluated using an alpha level of 0.05. Before performing the inferential analysis, the assumption of normality and homogeneity of variance of the collected data was completed first. For inferential statistics, a generalized estimating equation (GEE) model was used [35]. In accordance with Cohen (2013), the commonly used guidelines (d=0.2 indicates small; d=0.5 indicates medium; and d=0.8 indicates large) were applied to determine the intervention effect size [36].

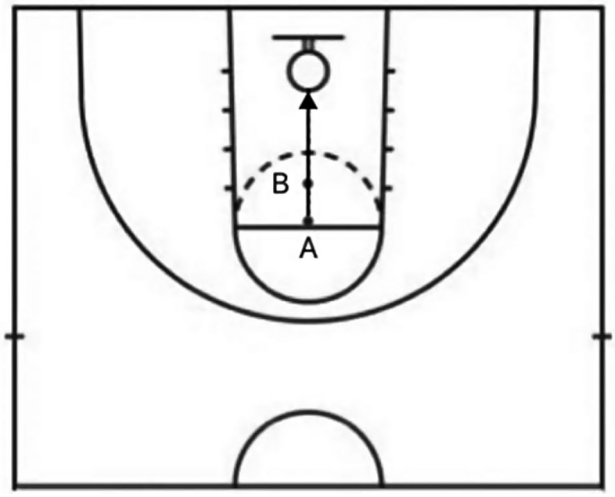

Fig. 2 Set shot

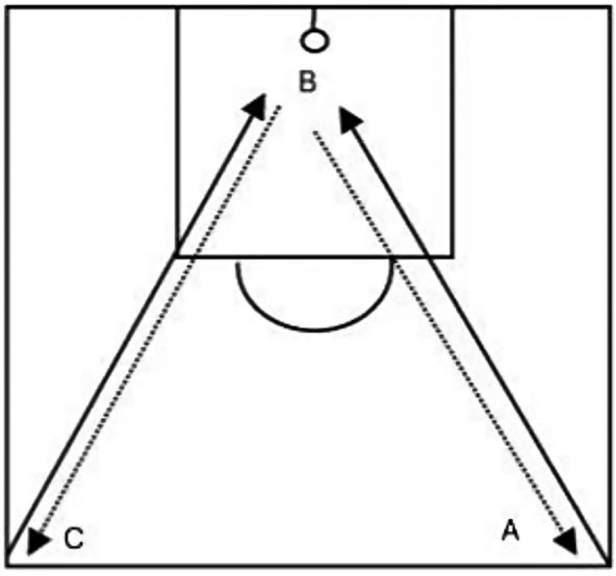

Fig. 3 Half-court dribbling and shooting

Results

Table 3 summarizes the comparative results of exercise attitudes and basketball skills between the blended learning and traditional learning models. While both models led to improvements, the blended learning model demonstrated significantly superior outcomes among university students.

Regarding exercise attitudes, both groups showed significant time effects from the pretest (T0) to the posttest (T16). However, the improvements in the blended learning group were notably greater than those in the traditional learning group. Specifically, the blended learning group demonstrated significantly greater effect sizes in behavior attitude (d=0.98), target attitude (d=0.63), behavior cognition (d=1.92), behavior intention (d=1.83), emotional experience (d=0.57), behavior control (d=0.87), and subjective norm (d=0.68), indicating that the blended learning model was more effective in enhancing students' positive exercise attitudes.

With respect to basketball skills, both groups showed significant improvements in set shots and half-court dribbling and shooting (HCDS). However, the improvements were more pronounced in the blended learning group. Compared with the traditional learning group, the blended learning group presented greater effect sizes in set shots (d=0.56) and HCDS (d=0.46), indicating that the blended learning model was more effective in enhancing basketball skills.

Discussion

This study examined the effects of a blended learning model on university students' exercise attitudes and basketball skills through a cluster randomized controlled trial. The results indicate that blended learning can significantly improve university students' exercise attitudes. This finding is consistent with previous findings that the blended learning model can improve students' behavior attitude [37, 38], target attitude [11, 39], behavior cognition [37], behavior habit [11], behavior intention [37, 39], emotional experience [11, 40], behavior control [11], and subjective standards [11, 37].

The observed improvement in exercise attitudes can be explained through the self-determination theory (SDT), which emphasizes the importance of autonomy, competence, and relatedness in enhancing intrinsic motivation and engagement in physical activities [41]. The blended learning model encourages students to participate more actively in the sport by increasing their autonomy [42]. Moreover, the blended learning model combines online and offline learning methods to provide a more personalized learning experience, aligning with the principles of Self-Regulated Learning Theory (SRL), which supports the idea that students learn more effectively when they manage their learning process [16, 43, 44]. Students have the flexibility to learn knowledge and skills at their own pace, which enhances the affirmative evaluation of exercise behavior [45].

Target attitudes refer to individuals' positive, negative, or neutral evaluations of exercise at various levels. In a blended learning model, personalized learning allows students to better understand the key points and difficulties of their skills, which enhances their target attitudes [46]. In addition, rich learning resources, such as online videos and interactive exercises, help students gain a more comprehensive understanding of motor skills and theoretical knowledge, thus improving their cognitive ability [39]. Through diverse learning contexts and stimuli, students can better develop regular exercise habits and behavioral intentions [11].

Table 3 Effects of blended learning on exercise attitude and basketball skills

Variables		Time	Measurement		Between-group		Within-group d	
			TL (M ± SD)	BL (M ± SD)	p	d	TL	BL
Exercise attitude	Behavior Attitude	T0	25.9(4.3)	24.7(3.3)	0.164	0.33	0.56	1.82
		T16	28.1(3.5)	32.3(4.8) *	< 0.001	0.98		
	Target Attitude	T0	42.7(6.9)	41.1(6.2)	0.305	0.24	0.46	1.29
		T16	45.6(5.5)	49.6(6.9) *	0.008	0.63		
	Behavior Cognition	T0	21.7(2.5)	22.2(2.7)	0.394	0.20	2.07	4.65
		T16	27.8(3.4)	33.2(2.0) *	< 0.001	1.92		
	Behavior Habit	T0	23.7(4.6)	23.3(3.2)	0.652	0.11	0.17	0.03
		T16	24.4(3.9)	24.7(5.6)	0.809	0.06		
	Behavior Intention	T0	25.5(3.4)	24.1(4.0)	0.121	0.37	0.17	2.16
		T16	26.0(3.2)	31.9(3.2) *	< 0.001	1.83		
	Emotional Experience	T0	35.4(6.5)	34.8(6.1)	0.686	0.10	0.35	1.01
		T16	37.5(5.3)	40.4(4.9) *	0.016	0.57		
	Behavior Control	T0	30.7(5.0)	29.5(3.7)	0.242	0.28	0.19	1.59
		T16	31.7(5.0)	35.6(4.0) *	< 0.001	0.87		
	Subjective Standard	T0	21.1(3.4)	20.4(3.3)	0.412	0.19	0.02	0.83
		T16	21.1(3.2)	24.1(5.3) *	0.004	0.68		
Basketball skills	Set Shot	T0	22.5(9.3)	21.9(6.7)	0.719	0.08	1.93	3.41
		T16	38.7(7.4)	42.4(5.3) *	0.017	0.56		
	HCDS	T0	17.9(6.3)	18.2(6.0)	0.857	0.04	1.61	2.54
		T16	30.7(9.4)	34.6(6.9) *	0.049	0.46		

Note TL, traditional learning; BL, blended learning; T0, preintervention test; T16, 16-week postintervention test; HCDS, half-court dribbling and shooting; M, mean; SD, standard deviation; d, effect size; *, the mean difference is significant at the 0.05 level

The blended learning model enhances students' emotional experience and behavior control [47]. According to Bandura's Social Cognitive Theory, real-time feedback and peer support can increase students' self-efficacy, which is a core component of behavioral control [48, 49]. Online forums and discussion groups also enhance the frequency of student interactions, improving their subjective standards and self-confidence in physical activity [50]. From a learning management perspective, the combination of online and offline instruction in the blended learning model enables more effective tracking of student progress and engagement [16]. This model assists teachers in monitoring student progress and providing timely support, thereby optimizing the overall learning management [51]. Furthermore, it allows educators to adjust the difficulty of learning materials and the pace of instruction according to individual student needs [45]. This personalized adaptation contributes to improved overall learning outcomes. Overall, the blended learning model effectively improves university students' exercise attitudes by increasing student autonomy, providing personalized learning experiences, and enhancing interaction and engagement.

In addition, this study compared students' exercise attitudes between blended and traditional learning models over 16 weeks. The results revealed a significant difference in exercise attitudes between the two models, except behavior habits ($p=0.809$, $d=0.06$). Several studies support this finding [39, 40]. The lack of significant improvement in behavior habits can be explained by the habit formation theory [52], which suggests that habit formation requires long-term repetition and consistency, and a weekly basketball course may not be sufficient to establish new habits for students without a basketball foundation. Research by Gardner, Rebar, and Lally (2022) suggests that it takes an average of 66 days to form a new habit, whereas more complex behavior habits may take longer [53]. Thus, even though blended learning can significantly improve attitudes and behaviors in other areas in the short term, changes in behavior habits may require longer interventions and persistence. Therefore, longitudinal studies are needed to explore the differences between blended and traditional learning models concerning university students' behavioral habits.

Physical education is essential in developing students' motor skills [54]. The results of the study revealed that both blended learning and traditional learning were effective at improving students' basketball skills, but the improvement was more significant with the blended learning model. These results are consistent with the findings of Syafi'i et al. (2021), who conducted an experiment on basketball skills in Indonesia and reported that students in a blended learning group significantly improved their basketball skills [55]. Similarly, Ding and Zhai (2023) experimented with the basketball skills of 90 male university students and reported significant

improvements in their basketball skills under a blended learning model [56]. Similar studies have also reported positive effects of blended learning on other sports skills, such as soccer [57], volleyball [58, 59], badminton [60], and dance [61]. Research has shown that blended learning models are effective in improving motor skills. This can be attributed to the scaffolding provided in blended learning, which is rooted in Vygotsky's sociocultural theory [62]. Students can preview knowledge and skills before class through online instructional materials, allowing class time to be more focused on practicing and correcting movements, thus helping students acquire motor skills better [63–65]. From a learning management perspective, this approach optimizes classroom time for student practice and enables instructors to provide more targeted feedback to address specific skill gaps [66]. Online assignments and quizzes also enhance the monitoring of student performance, which informs instructional adjustments [67]. This model supports adaptive learning strategies, allowing instruction to be continuously adjusted based on student progress [68].

Research has also shown that although traditional learning models are effective in improving basketball skills, their effectiveness is limited by teachers' teaching abilities and motor skill levels, resulting in uneven student performance [69]. In addition, traditional learning methods are less effective at improving students' exercise awareness and active learning [70, 71]. In contrast, blended learning models provide more flexible interaction and differentiated instructional support through personalized learning paths and diverse learning resources, which are more effective in stimulating students' motivation and intention to participate, thus significantly improving their basketball skills and overall learning experience [11, 72]. For educators and administrators, the implementation of blended learning models presents new opportunities for optimizing resource allocation [16]. Blended learning, through digital tools, enhances the scalability of teaching and eases the management of large classes by supplementing face-to-face instruction with online content [73]. Additionally, blended learning models help optimize classroom time, allowing teachers to prioritize skills training in practical courses while delivering theoretical knowledge through self-paced online modules [74].

However, two studies reported different results. For example, Zhao, Chen, and Liu (2010) reported no differences in students' combination skills after a 12-week instructional intervention [30]. The reason for the non-significant difference could be that acquiring combination skills requires an understanding of the concepts and emphasizes practical practice among the learners. In addition, more than 90% of the learners were beginners with no experience in badminton, thus making it difficult to improve their badminton combination skills in a limited period. Similarly, Bayyat's (2020) study revealed no significant difference in ballet skills between blended and traditional learning models after 14 weeks [26], highlighting the potential variability in results depending on the specific sport or learning context.

In conclusion, this study suggests that blended learning is effective in improving university students' exercise attitudes and basketball skills. By offering a more engaging, flexible, and efficient learning experience, blended learning can play a positive role in physical education. These findings carry important implications for the design and implementation of university physical education programs.

Although the results of the study are encouraging, there are several limitations. The relatively small sample size and the fact that the study was conducted at one university may limit the generalizability of the findings. Variations in intervention programs and durations may have influenced the outcomes, making it difficult to draw definitive conclusions. Further research with larger, more diverse samples is needed to validate these findings. Additionally, long-term follow-up studies are essential to assess the sustainability of the observed improvements in exercise attitudes and basketball skills. Moreover, future research should explore the mechanisms underlying the effectiveness of blended learning in physical education. Investigating factors such as student engagement, motivation, and the specific components of blended learning that drive success would provide deeper insights into optimizing this educational approach.

Abbreviations

TL	Traditional learning
BL	Blended learning
MOOC	Massive open online course
HCDS	Half-court dribbling and shooting
M	Mean
SD	Standard deviation
d	Effect size
CRCT	Cluster randomized controlled trial
GEE	Generalized estimating equation

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Author contributions

CW: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. YY: Conceptualization, Data curation, Formal analysis, Writing – review & editing. XJ: Methodology, Writing – review & editing.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical approval
This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Universiti Putra Malaysia (Approval No. JKEUPM 2022–030).

Consent for publication
Not applicable.

Informed consent
All the students voluntarily participated in the study and provided informed consent.

Competing interests
The authors declare no competing interests.

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