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Circuit training exercise model through the explosive power of the leg muscles of badminton extracurricular players

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ABSTRACT
The explosiveness of the leg muscles is an important component in supporting the performance of badminton athletes, especially for students who are members of extracurricular activities. This study aims to develop and test the effectiveness of circuit training models in increasing the explosiveness of leg muscles of high school badminton extracurricular students in Palembang City. The method used is research and development (Research and Development) involving expert validation and field trials. The validation results showed that the developed exercise model scored an average of 73.75% from academics, practitioners, and movement experts, which was included in the good category and worth testing. The small group trial at SMAN 8 Palembang obtained a result of 94.67%, while the large group trial at SMAN 9 Palembang showed a score of 92.5%. These results indicate that the circuit training model is very effective in increasing the explosive power of the leg muscles of high school badminton players. The conclusion of the circuit training model has proven to be effective and very good in increasing the explosiveness of the leg muscles of extracurricular badminton students. Practice model suggestions can be widely implemented by coaches or sports teachers as an alternative to physical exercise in badminton extracurricular activities in schools, as well as further research to test the effectiveness at different levels of education.

Keywords: circuit training; explosiveness; leg muscles; badminton; extracurricular

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INTRODUCTION

Muscular leg power is a critical biomotor component in various sports, particularly in activities that require jumping, acceleration, and rapid transfer of force(Nugroho et al., 2022). In the context of competitive sports, explosive power serves as a key determinant of striking force, movement speed, and the effectiveness of technical performance(Fadillah & Dewi, 2021). In badminton, lower-

limb explosive power plays a dominant role in generating the vertical lift and force needed to execute a smash, a widely used offensive technique to secure points. Badminton is one of the most popular sports and can be played by individuals across different age groups, both male and female, in singles or doubles formats (Putra et al., 2024). Technically, badminton requires mastery of racket grip, stroke techniques, and footwork, where the ability to perform an optimal smash is strongly influenced by the explosive power of the lower limbs.

Previous studies have examined various training methods that effectively enhance lower limb explosive power. Circuit training has been shown to improve both leg and arm explosive strength among basketball athletes (Putri et al., 2020). This method incorporates multiple training stations, providing exercise variation that reduces monotony while simultaneously developing strength, agility, and endurance. In addition, plyometric knee tuck jump training has been found to significantly increase lower limb explosive power in high school students(Ardiansyah et al., 2023). These findings reinforce the notion that explosive and repetitive training methods can produce substantial improvements in lower limb muscular power.

The literature on circuit training indicates that this method is a combination of strength, aerobic, agility, and speed exercises performed across multiple stations in a sequence of structured movements (Hakim et al., 2020; Prasetyo et al., 2022). This training model is designed to enhance overall muscular strength and has been widely applied across various sports disciplines. Circuit training is regarded as an effective method for improving muscular endurance and explosive power . Through its principle of executing several exercise stations in a consecutive manner, circuit training is considered capable of enhancing athletes' strength, speed, and endurance.

Although numerous studies have demonstrated the effectiveness of circuit training and plyometric exercises in improving muscular explosive power (Putri et al., 2020), Research that specifically examines the application of circuit training within the context of badminton particularly for enhancing lower limb explosive power related to smash performance remains limited (Saputra & Gunawan, 2021); (Hariadi et al., 2022). Most previous studies have been conducted in other sports, such as basketball, and on student populations with different physical conditions (Wicaksono & Syafei, 2023). Furthermore, empirical investigations on the implementation of circuit training in school based extracurricular programs are still scarce, especially those focusing on improving smash technique (Purnama & Mahfud, 2023).

Based on observations conducted at SMA Negeri 9 Palembang on May 7, 2024, it was found that students participating in the badminton extracurricular program had not yet received a training regimen specifically designed to improve lower-limb explosive power (Setiawan et al., 2021). This was evident from the insufficient power demonstrated during smash execution, as many students were unable to produce strong and accurate shots (Hariadi et al., 2022). This condition indicates a discrepancy between the technical demands of badminton performance and the training program provided to the students (Subarkah & Marani, 2020).

This gap underscores the importance of conducting the present study, particularly the need to implement an effective training method to enhance lower-limb explosive power as a key component in executing the smash technique (Bompa & Buzzichelli, 2022). This research offers a novel contribution by applying the circuit training method specifically to high school badminton athletes/extracurricular participants, whereas previous applications have predominantly focused on sports other than badminton (Hariadi et al., 2022)Accordingly, this study not only introduces an innovative approach to training but also provides practical benefits for coaches in improving students' smash performance (Kusuma & Pratama, 2023).

The purpose of this study is to develop and validate a circuit training model aimed at improving lower-limb explosive power among students participating in the badminton extracurricular program at SMA Negeri 8 and SMA Negeri 9 Palembang. Using a Research and Development (R&D) approach, this study evaluates the feasibility, practicality, and acceptability of the developed training model as a structured program to enhance the physical capability that supports smash performance in high school badminton players.

METHODS

This study employed a Research and Development (R&D) design aimed at producing a circuit training model and examining its effectiveness in improving lower-limb explosive power (Sugiyono, 2020). The development process followed the ADDIE model, which consists of the stages of analysis, design, development, implementation, and evaluation. The research participants were 35 male students aged 16–18 years who were enrolled in badminton extracurricular activities at SMA Negeri 8 and SMA Negeri 9 Palembang. Participants were selected purposively based on the consideration that they had not previously received a structured training program designed to enhance lower-limb explosive power, as indicated by their inadequate strength when performing smash techniques.

The research design followed the ADDIE framework systematically. In the analysis stage, the researcher identified the problems and gathered preliminary data through direct observation of extracurricular activities (Sugiyono, 2021). The design stage included constructing the circuit training model, which consisted of several exercise components such as squats, lunges, front jumps, and scissor jumps with a box (Prasetyo et al., 2022). The development stage involved validating the model with two academic experts and one badminton practitioner, followed by revisions based on the feedback provided. The implementation stage consisted of two phases of model testing: a small-scale trial involving 15 students selected through random sampling, and a large-scale trial involving 20 students to evaluate the model's effectiveness after revision. The evaluation stage was conducted by reviewing the trial results and expert feedback to determine the feasibility of the training model.

Data were collected through observation, documentation, and questionnaires administered to both experts and participants (Sugiyono, 2021). The expert questionnaires assessed the feasibility, appropriateness, and safety of the training model, while the participant questionnaires evaluated the practicability and acceptability of the exercises. The data were analyzed using descriptive quantitative techniques through percentage calculations. The resulting percentages were categorized into five assessment levels: Poor, Fair, Adequate, Good, and Very Good.

The research procedures began with the preparation of instruments and an initial observation, followed by the design of the training model. After undergoing expert validation in the development stage, the model was tested in a small-scale trial to identify initial weaknesses, revised accordingly, and then tested in a large-scale trial. All research procedures were carried out in accordance with ethical standards and the academic guidelines of Universitas Bina Darma Palembang, and were conducted after the completion of the proposal examination.

FINDINGS AND DISCUSSION

Findings

The circuit training model designed to improve lower-limb explosive power in badminton has undergone a series of feasibility assessments involving an academic expert, a badminton practitioner, and a movement specialist. These feasibility evaluations were conducted to examine the appropriateness, accuracy, safety, practicality, and overall benefits of the training model in relation

to the physiological and skill-related needs of the participants. Expert assessments were carried out using a four-point rating instrument, as presented in the following tables.

The validation was carried out by a lecturer in Sports Education at Universitas Bina Darma. Ten aspects were evaluated to assess the initial feasibility of the training model. The results of the evaluation are presented in Table 1.

Table 1. Validation by Badminton Academic Expert

No.	Aspects Assessed	Rating Scale			
		1	2	3	4
1.	Compatibility of the developed model with the training program.			✓	
2.	The compatibility between the objectives of the exercise in improving students' skills.			✓	
3.	The accuracy of the content of the exercise model in increasing the explosiveness of the students' leg muscles.			✓	
4.	The accuracy of the content of the developed training model is in accordance with the characteristics of the to students 16-18 years old (high school).			✓	
5.	Safety of the developed training model.				✓
6.	The ease of the training model developed for students.				✓
7.	Practicality of the Developed Training Model			✓	
8.	The training model developed can increase the activeness of students.			✓	
9.	The developed exercise model can optimize the explosiveness of the leg muscles				✓
10.	The training model developed can optimize students' ability to apply smash techniques in the game of Badminton		✓		

Based on Table 1, the training model obtained a feasibility score of 80%, indicating that it is suitable for use and for experimentation at both small and large scales. This assessment demonstrates that the model aligns with training principles, the characteristics of high school students, and the objective of enhancing lower limb explosive power in the context of badminton smash technique.

The next validation was conducted by a badminton practitioner who also serves as a lecturer at Universitas Bina Darma. The purpose of this validation was to assess the feasibility of the model from a practical and field-applicative perspective. The validation results are presented in Table 2.

Table 2. Validation by Badminton Practitioner

No.	Aspects Assessed	Rating Scale			
		1	2	3	4
1.	Compatibility of the developed model with the training program.			✓	
2.	The compatibility between the objectives of the exercise in improving students' skills.			✓	
3.	The accuracy of the content of the exercise model in increasing the explosiveness of the students' leg muscles.			✓	
4.	The accuracy of the content of the developed training model is in accordance with the characteristics of the to students 16-18 years old (high school).			✓	
5.	Safety of the developed training model.				✓
6.	The ease of the training model developed for students.				✓
7.	Practicality of the Developed Training Model			✓	
8.	The training model developed can increase the activeness of students.			✓	
9.	The developed exercise model can optimize the explosiveness of the leg muscles				✓
10.	The training model developed can optimize students' ability to apply smash techniques in the game of Badminton			✓	

The evaluation results indicate that the training model is appropriate for students aged 16–18 years, easy to implement, safe, and capable of optimizing lower-limb explosive power and smash performance. The practitioner's assessment reinforces that the model is relevant for application in school-based badminton extracurricular activities.

The movement-expert validation was carried out by a lecturer from Universitas Bina Darma. The purpose of this validation was to ensure the feasibility of the training model from biomechanical and motor-physiological perspectives. The expert's assessment is presented in Table 3.

Table 3. Validation by Movement Expert

No.	Aspects Assessed	Rating Scale			
		1	2	3	4
1.	Compatibility of the developed model with the training program.			✓	
2.	The compatibility between the objectives of the exercise in improving students' skills.			✓	
3.	The accuracy of the content of the exercise model in increasing the explosiveness of the students' leg muscles.			✓	
4.	The accuracy of the content of the developed training model is in accordance with the characteristics of the to students 16-18 years old (high school).			✓	
5.	Safety of the developed training model.				✓
6.	The ease of the training model developed for students.				✓
7.	Practicality of the Developed Training Model			✓	
8.	The training model developed can increase the activeness of students.			✓	
9.	The developed exercise model can optimize the explosiveness of the leg muscles			✓	
10.	The training model developed can optimize students' ability to apply smash techniques in the game of Badminton				✓

The movement expert's evaluation indicates that all aspects of the training model meet the feasibility criteria, including the appropriateness of the training content, safety, and its effectiveness in enhancing lower-limb explosive power.

To examine the consistency among experts, a Content Validity Ratio (CVR) and Content Validity Index (CVI) analysis was conducted on ten statements assessed by three experts (E1, E2, E3). The results of the analysis are presented in Table 4.

Table 4. Results of CVI and CVR Analysis

Questions	E1	E2	E3	ne	N	N/2	ne-(N/2)	CVR	Criteria
1	3	3	3	3	4	2	1	0,33	Valid
2	3	3	3	3	4	2	1	0,5	Valid
3	3	3	3	3	4	2	1	0,5	Valid
4	3	3	3	3	4	2	1	0,5	Valid
5	4	4	4	3	4	2	1	0,5	Valid
6	4	4	4	3	4	2	1	0,5	Valid
7	3	3	3	3	4	2	1	0,5	Valid
8	3	3	3	3	4	2	1	0,5	Valid
9	4	4	4	3	4	2	1	0,5	Valid
10	2	3	3	2	4	2	0	0	Valid
Sum	32	34	35			Sum		0,5	Valid
Average	3	3,5	3,5			Average		0,5	Valid
Average		3,7							

The analysis indicates that all items are classified as valid, with an average CVR value of 0.5, which meets the validity threshold according to Lawshe's standard for three evaluators. Thus, all components of the training model are deemed feasible for implementation.

The training model was tested in two phases: a small-scale trial involving 15 students and a large-scale trial involving 20 students. The assessment was conducted using questionnaires designed to measure feasibility, practicality, and students' responses to the training model. The results of the assessment are presented in the following table.

Table 5. Results of Small-Scale and Large-Scale Trial Questionnaires

No	Name	Score	Percentage (%)	Trial Category
1	MR	40	100	Small-scale
2	MR	37	92,5	Small-scale
3	RE	38	95	Small-scale
4	PA	40	100	Small-scale
5	MR	38	95	Small-scale
6	AM	37	92,5	Small-scale
7	MKDA	38	95	Small-scale
8	SH	40	100	Small-scale
9	AWS	40	100	Small-scale
10	WP	36	90	Small-scale
11	NBK	38	95	Small-scale
12	RA	36	90	Small-scale
13	MK	36	90	Small-scale
14	A	36	90	Small-scale
15	RP	38	95	Small-scale
16	YP	40	100	Large-scale
17	MRA	36	90	Large-scale
18	AA	36	90	Large-scale
19	AHN	40	100	Large-scale
20	MKA	36	87,5	Large-scale
21	FF	36	90	Large-scale
22	MBK	40	100	Large-scale
23	MFR	36	90	Large-scale
24	MA	35	87,5	Large-scale
25	SMI	38	95	Large-scale
26	AW	30	75	Large-scale
27	RN	40	100	Large-scale
28	FA	36	90	Large-scale
29	EA	40	100	Large-scale
30	FOR	35	87,5	Large-scale
31	DCM	36	90	Large-scale
32	FDI	38	95	Large-scale
33	AMR	40	100	Large-scale
34	AAA	36	90	Large-scale
35	MAN	40	100	Large-scale

The trial results indicate that all students provided evaluations within the "Good" to "Very Good" categories, with percentage scores ranging from 75% to 100%. These findings demonstrate that the circuit training model is easy to understand, practical to implement, and perceived as providing direct benefits in enhancing physical capabilities, particularly lower-limb explosive power. It is clarified that participants are identified by initials in Table 5; the repeated initials (e.g., "MR" in rows 1, 2, and 5) represent different students whose full names share the same initials, not duplicate entries. Data from the small-scale trial (rows 1–15, SMAN 8 Palembang) and large-scale trial (rows 16–35, SMAN 9 Palembang) are distinct and clearly delineated by the Trial Category column.

Overall, the validation results from the three experts, along with the findings from both the small-scale and large-scale trials, indicate that the developed circuit training model is feasible, practical, safe, and effective for use as a training program to enhance lower-limb explosive power in

badminton, particularly in supporting the smash skills of high school students. In summary, the average expert validation score was 73.75% (Good category), the small-scale trial yielded 94.67% (Very Good), and the large-scale trial produced 92.5% (Very Good), confirming the overall feasibility of the model.

Discussion

The recapitulation of the training model trials indicates that the total number of respondents involved in both the small-scale and large-scale trials was 35 students. With a maximum possible score of 1,400 points (35 students × 40 points), the total score obtained was 1,311 points, consisting of 568 points in the small-scale trial and 743 points in the large-scale trial. Based on these results, the average feasibility percentage of the training model reached 93.64%, indicating that the circuit training model falls within the "very good" category and is deemed feasible for use as a training program to improve lower-limb explosive power among high school badminton extracurricular participants. This finding is further supported by the results of the large-scale trial involving 20 students at SMAN 9 Palembang, which showed an average percentage of 92.5%, confirming that the model possesses excellent quality and is ready for implementation in instructional and extracurricular contexts.

The development process of the training model followed a series of stages in accordance with research and development procedures, beginning with the design phase, which involved compiling materials and information from various literature sources, including journals and books (Sugiyono, 2020). After completing the model design, expert validation was conducted involving three qualified validators namely a badminton practitioner, a badminton academic, and a movement expert who are all lecturers at Universitas Bina Darma and hold national-level badminton certifications. The expert validation yielded an average score of 73.75%, indicating that the model falls within the "good" category and is suitable for use.

Subsequently, a small-scale trial was conducted at SMAN 8 Palembang involving 15 badminton extracurricular students. At this stage, data were collected using questionnaires to assess the model's feasibility, practicality, and student responses. After the small-scale trial demonstrated satisfactory results, the study proceeded to a large-scale trial at SMAN 9 Palembang involving 20 students. Data collection in this stage employed the same instrument to ensure assessment consistency. The small-scale trial produced a feasibility percentage of 94.67%, while the large-scale trial yielded a score of 92.5%. Both results consistently fall within the "very good" category.

Overall, the series of expert validations and field trials demonstrate that the developed circuit training model meets quality standards, is feasible for implementation, safe, and effective in enhancing students' lower-limb explosive power. Therefore, this model can be recommended as an applicable and relevant training program for high school badminton extracurricular activities, particularly in supporting the mastery of smash techniques that require explosive leg strength (Hariadi et al., 2022).

The improvement in feasibility scores indicates that the structured implementation of circuit training contributes positively to the development of lower-limb explosive power. Explosive power is a crucial biomotor component in badminton, particularly in executing effective smash techniques that require vertical lift and rapid force production (Nugroho et al., 2022). The repetitive and station-based characteristics of circuit training allow athletes to stimulate neuromuscular adaptations systematically. This aligns with the principle of progressive overload in sports training, where consistent and structured stimuli lead to performance improvements (Bompa & Buzzichelli, 2022). Furthermore, circuit training integrates strength and speed elements simultaneously, making it

suitable for sports that demand dynamic lower-body movements (Prasetyo et al., 2022). Therefore, the high percentage results obtained in this study are theoretically supported by established training principles.

From a technical perspective, smash performance in badminton is influenced not only by upper-body coordination but also by lower-limb explosive strength. The ability to generate upward thrust during jumping directly affects shuttlecock speed and shot accuracy (Nugroho et al., 2022) (Saputra & Gunawan, 2021). Previous findings have shown that leg muscle explosive power significantly contributes to smash effectiveness (Hariadi et al., 2022).In this context, the circuit training model developed in this study provides a targeted approach to strengthening the specific physical component required in badminton. Compared to general physical training programs, a structured circuit design enables athletes to focus on movement patterns that closely resemble game situations. This specificity principle enhances transferability from training to actual match performance (Setiawan et al., 2021).

In addition, the positive student responses during both small- and large-scale trials indicate that the training model is not only effective but also practical and engaging. Practicality is an important aspect of training implementation in school-based extracurricular programs, where time allocation and facility limitations must be considered. Structured and varied exercises can increase student motivation and participation levels (Ichsanudin & Gumantan, 2020). The combination of bodyweight exercises such as squats, lunges, and jumps allows the program to be implemented without complex equipment. This makes the model adaptable to various school environments while still maintaining its effectiveness in improving physical capacity. Thus, the model demonstrates both pedagogical and physiological relevance.

Furthermore, the findings of this study are consistent with previous research indicating that circuit training improves physical fitness components, including muscular endurance and explosive power (Hakim et al., 2020). Although earlier studies were conducted in different sports contexts, such as futsal and football, the physiological mechanisms underlying explosive power development remain similar. The adaptation process involving motor unit recruitment and increased muscle contraction speed supports improvements in dynamic movements (Rahman & Suhartini, 2022). Therefore, applying circuit training in badminton extracurricular activities represents an innovative yet theoretically grounded approach. The present study strengthens the empirical evidence that circuit-based programs can be effectively adapted to sport-specific performance enhancement at the high school level.

CONCLUSION

This research and development study produced a Circuit Training model designed to enhance lower-limb explosive power in high school badminton extracurricular participants in Palembang. Based on validation by three experts and the results of both small- and large-scale trials, the model has been validated as feasible and well-received by participants, and is suitable for implementation in extracurricular training contexts. It should be noted that, as this study employed expert validation and questionnaire-based trials rather than pre-test and post-test experimental measurements, effectiveness claims should be understood as reflecting perceived feasibility and participant acceptance rather than empirically proven training outcomes. Future research incorporating pre-test and post-test designs is recommended to verify the model's actual impact on explosive power. The developed model is not only physiologically relevant but also practical and easily applied by both coaches and students. Therefore, this training model is recommended as an innovative alternative

program to improve physical abilities, particularly lower-limb explosive power. Future research is expected to further develop the model by incorporating additional training variations that are adaptable to students' needs, thereby maximizing its benefits.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interest that could influence the implementation and results of this research.

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