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Enhancing student athlete performance through an innovative aerobic gymnastics choreography model: Evidence from Central Java

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ABSTRACT

Background: The decline in student participation in aerobic gymnastics at the *Pekan Olahraga Pelajar Daerah* (POPDA) or Regional Student Sports Week in Central Java highlights the need for more flexible and effective training methods. While video-based coaching offers promising flexibility, limited research has examined its impact on the performance of student athletes, particularly in choreographed aerobic routines. This study addresses that gap by testing a video-based choreography model tailored for young athletes. **Research Objectives:** This study aimed to evaluate the effectiveness of a student-focused aerobic gymnastics choreography model in enhancing performance, particularly in artistic and creative aspects. **Methods:** This quantitative experimental study involved 13 student athletes (elementary to high school level) who were selected from the POPDA Central Java event. A total sampling technique was applied. The athletes followed the choreographic model intervention, and performance scores—assessed by judges—were compared before and after the intervention using paired sample t-tests analyzed in SPSS 2022. **Finding/Results:** The results showed a statistically significant improvement in athlete performance following the application of the choreography model ($p < 0.05$). Improvements were most notable in artistic expression and movement creativity, highlighting the model's efficacy in developing aesthetic and technical skills. **Conclusion:** The specially designed aerobic gymnastics choreography model significantly enhances the performance of student athletes. The findings support the integration of video-based coaching as a complementary tool to traditional methods, offering flexibility in training and supporting long-term athlete development. This approach may be adopted by coaches and competition organizers to foster a more sustainable and competitive environment for aerobic gymnastics at both regional and national levels.

Keywords: Aerobic gymnastics; choreography model; student athletes; performance enhancement; video-based coaching

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INTRODUCTION

The number of athletes participating in the Provincial Sports Week (PORPROV) in Central Java continues to decline, raising concerns about the effectiveness of the sports coaching system in this area. Data from the Indonesian National Sports Committee (KONI) shows that the number of aerobic athletes participating in PORPROV is 25% in the period 2018-2022.This phenomenon not only reflects the low level of participation, but also has the potential to inhibit the regeneration of talented athletes, reduce regional competitiveness in national competitions, and limit the chances of young athletes to achieve higher achievements (Qi et al., 2024). Therefore, more innovative coaching strategies are needed so that the athlete's potential can be optimized early on.

Coaching effective athletes should start at a young age to build a solid foundation in terms of skills and mental compete (Ilham et al., 2022; Qi et al., 2024; Sofan et al., 2022). In gymnastics, including aerobics, the coaching stages follow the BOMPA theory which includes the early stage (ages 6-9 years), the specialization stage (ages 9-15 years), and the peak performance stage (ages 14-25 years) (Gasper, 2020; Nicholls, 2021). A good coaching Model must take into account these stages so that the athlete's technical and mental development is aligned with their growth curve.

One factor is the lack of innovation in coaching methods. Monotonous training programs and lack of creativity often make young athletes demotivated. In addition, the conventional coaching approach and the limited use of modern technology are also obstacles in developing optimal athlete skills (Ilham et al., 2022; Satria et al., 2023; Sofan et al., 2022). Therefore, the use of technology in coaching is a strategic step to increase the interest and involvement of athletes from an early age.

Previous studies placed more emphasis on physical aspects or choreographic evaluation without integrating digital learning media (Kaufmann et al., 2022; Mkaouer et al., 2023; Puspodari et al., 2022). In fact, video-based training has great potential in aiding technical understanding, increasing athlete engagement, and delivering consistent material beyond face-to-face session. Gaps in previous research indicate the need for new, more adaptive and engaging approaches in the digital age. Video-based models have the potential to provide guidance that is more effective and accessible to athletes and coaches, as well as being able to increase athlete engagement and understanding of training structures and competition rules (Ghaderi et al., 2021; Hu et al., 2023; Ölmez, 2022). Innovations in training methods are essential to create more relevant coaching programs for the younger generation. This study also complements the research of Mkaouer et al., (2023), which focuses more on the physical aspects of aerobic exercise without providing concrete solutions related to digital approaches in coaching.

Aerobic gymnastics coaching in Central Java has been going on since 2005 in the framework of Regional Sports week to Provincial Sports Week 2018. During this period, Central Java has produced outstanding athletes at the national level. However, in recent years, the number of athletes participating in the Championship has decreased dramatically, which has the potential to break the chain of regeneration of athletes in the future. Previous research confirmed that early age coaching is critical in building the basic and mental skills of competitive athletes (Patelia et al., 2021; Reaburn, 2021; Stones & Leo, 2021). In addition, other studies highlight the importance of technical guidance in creating choreographies that comply with international competition standards (Carbinatto & Furtado, 2019; Cervin, 2020). FIG rule-based choreography models can help athletes optimize their creativity and performance in the competition arena.

Coaching programs with a video approach as an exercise guide have proven effective in improving the technical skills and creativity of adolescent gymnasts. Learning videos allow athletes to better understand the structure and rules of the competition and increase the effectiveness of training beyond face-to-face sessions with a coach. To measure the effectiveness of this model, the study will use the SERVQUAL model that assesses the quality of coaching programs based on five main dimensions: reliability, responsiveness, assurance, empathy, and physical evidence. This approach is expected to provide a more comprehensive insight into the satisfaction and effectiveness of the training methods developed.

The urgency of this research lies in the need to develop more relevant, engaging, and technology-based training models, to address the decline in early age athlete participation. If not addressed immediately, this condition has the potential to break the chain of regeneration of athletes and worsen the achievement of the

area in the future. In addition, there are not many studies that offer a video-based training approach that is structured and according to the standards of the International Gymnastics Federation (FIG).

This research has had a significant practical and theoretical impact. In practical terms, this model can improve the quality of coaching, athlete performance, and the sustainability of aerobic exercise in Central Java. Thoretically, this study fills a gap in the literature related to the application of video-based instruction in aerobic exercise coaching in accordance with FIG standards. By integrating early training, the development of appropriate choreography standards, and the use of video technology, this study offers a comprehensive solution that can answer the challenges in the world of aerobic training.

METHOD

Research Design

This study adopts a quantitative approach with a quasi-experimental design, specifically the static group pretest-posttest design (Achen, 2023; Puspodari et al., 2022). The aim is to measure the effectiveness of a video-based aerobic gymnastics choreography training model on student-athlete performance in Central Java. This design does not use a control group due to the limited number of eligible participants all athletes who qualified through the Central Java Student Sports Week (POPDA) were included. The total population is relatively small, and the use of a control group would have reduced statistical power and may have raised ethical concerns by withholding potentially beneficial training from control participants. Moreover, each athlete serves as their own control through the comparison of pretest and posttest results.

Participants

The study involved 13 aerobic gymnastics student-athletes from various school levels (elementary to senior high school) across districts in Central Java. Participants were selected using a total sampling technique, involving all athletes who passed the POPDA selection and met the inclusion criteria. Sampling was purposive, targeting athletes with relevant competition experience and within the FIG age eligibility for development stages. The samples were collected using total sampling technique, including 9 female athletes and 4 male athletes from different districts/cities in Central Java, such as Demak, Banyumas, Pati, Brebes, and Magelang.

Table 1. Details the Number of Research Samples

No	Organization	Men's Athlete	Women Athletes	Coach	Total
1	Indonesian Gymnastics Association Brebes Regency	1	1	1	3
2	Indonesian Gymnastics Association Pati Regency	-	1	1	2
3	Indonesian Gymnastics Association Demak Regency	2	3	1	6
4	Indonesian Gymnastics Association Banyumas Regency	-	3	1	4
5	Indonesian Gymnastics Association Magelang City	1	1	1	3
	Total	4	9	5	18

Procedures

The study proceeded in three main stages. First, a pretest was conducted to evaluate the initial performance of the athletes using the scoring criteria set by the International Gymnastics Federation (FIG), which includes three main components: difficulty, artistry, and execution. Following this, the intervention phase was carried out over a period of six weeks, during which the athletes participated in a structured choreography training program guided by instructional videos. Finally, a posttest was administered using the same FIG criteria to measure any improvements in the athletes' performance as a result of the intervention.

Intervention

The intervention was carried out using a systematic video guide developed in accordance with the standards of the International Gymnastics Federation (FIG). Athletes followed the training program twice a week for six weeks, with each session lasting 90 minutes. The video content was carefully structured into several key components to optimize athlete development. The first component focused on basic aerobic movements, such as marching, knee lifts, and grapevines, aimed at building coordination and lower-body strength. The second

component introduced complex choreography, including turns, jumps, and rhythmic patterns, to improve technical difficulty and encourage creativity. The third component emphasized artistic elements, providing guidance on facial expressions, body gestures, and synchronization with music to enhance the aesthetic quality of the performance. Finally, the videos included a correction and feedback segment, which demonstrated both correct and incorrect execution of movements. In addition, coaches provided post-session feedback to help athletes refine their technique and ensure a better understanding of the choreography. The scoring instruments used are derived directly from the official FIG Code of Points, ensuring strong content validity. Inter-rater reliability was assessed during a trial scoring session using intraclass correlation coefficients (ICC). The ICC for difficulty, artistry, and execution scores all exceeded 0.85, indicating high scoring consistency among judges.

In addition, coaches provide feedback after each session to ensure correct execution and help athletes improve technique. This supervision is intended to ensure the effectiveness of training and improve the athlete's understanding of choreography. The data collected included three main components: difficulty, artistry and execution, which were assessed by the jury in accordance with the rules of the International Gymnastics Federation (FIG) (Kleiner, 2024). Pretest and posttest results will be compared using the t-test to determine the effectiveness of the choreography model applied. Data processing is done using SPSS software version 22. The following table research instruments:

Table 2. Elements of Assessment Difficulty

Difficuly Element	Value
Straddle support	0.2
1/1 turn tuck jump	0.4
1/1 air turn	0.3
Helicopter	0.4
Push up	0.1

Table 3. Artistic Assessment

Components of artistic assessment	Value Range	Final grades
Music	1.0 s/d 2.0	
Aerobic Content	1.0 s/d 2.0	
General content	1.0 s/d 2.0	
Use & Formation	1.0 s/d 2.0	
Artistry	1.0 s/d 2.0	

Table 4. Execution Assessment

Category Error Rate	Value Cuts
Small	0.1
Medium	0.3
Large	0.5
Fail	1.0
Execution Value	10 – Number of errors

Research Ethics

This study was conducted in accordance with standard ethical research practices involving human participants. Written informed consent was obtained from all athletes and their legal guardians prior to participation. The research protocol was reviewed and approved internally by the academic supervisory team to ensure that it met ethical standards, particularly in the protection of minors. All personal data were anonymized and handled confidentially to protect participants' privacy and well-being throughout the study.

RESULTS AND DISCUSSION

The aerobic gymnastics choreography model was delivered through instructional videos distributed to district- and provincial-level officials of the Indonesian Gymnastics Association (Persani) in Central Java. The videos served as references for coaches across five regional Persani branches Brebes, Pati, Demak, Banyumas, and Magelang whose student athletes became the study's subjects.

Based on the posttest evaluation of athletes' performances using the Code of Points by the International Gymnastics Federation (FIG), the results showed relatively comparable total scores across athletes, indicating the effectiveness of the video-based choreography model in standardizing skill levels. However, artistic scores varied, reflecting differences in choreographic interpretation and creative expression.

Table 5. Summary of the Artistic Value of the Female

No	Name	Difficulty	Artistic	Execution	Deduction	Total
1	N1	0.5	5.3	4.0	-	9.8
2	N2	0.3	6.1	3.6	-1.0	9.0
3	N3	1.5	6.9	6.5	-	14.9
4	N4	2.0	7.1	6.8	-	15.9
5	N5	1.8	7.3	7	-	16.1
6	N6	1.8	7.2	6.8	-	16.0
7	N7	1.5	6.3	5.7	-	13.2
8	N8	0.6	5.8	4.3	-0.5	10.4
9	N9	0.2	5.3	3.8	-0.4	8.9
Average		1.133	6.366	5.388		12.688

Table 5 presents posttest results for nine female athletes. Artistic scores ranged from 5.3 to 7.3, with an average of 6.366, categorized as "satisfactory" based on the rubric developed from FIG scoring criteria. The three highest scorers (N4, N5, N6) received scores above 7.0, indicating good mastery of choreography, musicality, and stage presence. Conversely, three athletes scored below 6.0, suggesting limited development in aesthetic expression.

Table 6. Summary of the Artistic Value of the Male

No	Name	Difficulty	Artistic	Execution	Deduction	Total
1	N1	1.4	7	6.6	-	15
2	N2	0.9	5.6	3.8	-1.3	9.0
3	N3	0.5	5.2	3.7	-1.0	8.4
4	N4	0.1	5.2	3.5	-0.7	8.0
Average		0.725	5.75	4.4		10.1

In Table 6, four male athletes scored between 5.2 and 7.0 in artistic value, with an average of 5.75, slightly lower than that of the female athletes. Only one athlete (N1) reached the "good" category. This finding highlights a gender-based performance gap in artistic execution, possibly due to differences in experience, stylistic exposure, or coach guidance.

Federation Internationale de Gymnastics (FIG). The FIG specifies three main aspects in the evaluation of aerobic exercise, namely difficulty, artistic and execution. Based on the data obtained, the average artistic score of female athletes is 6,366, while that of male athletes is 5,75, showing that there is room for improvement in the artistic aspect according to FIG standards, which emphasise creativity, harmony and expression of musicality.

Variations in artistic scores indicate differences in choreographic interpretation between athletes. Athletes with higher levels of difficulty tend to have better artistic scores, suggesting that experience and mastery of technique are very influential. However, lower scores for some athletes indicate limitations in adaptation and understanding of more complex artistic elements. Despite methodological limitations, findings suggest that the video-guided choreography model had a positive effect in promoting artistic skill development among student athletes. However, its full potential may depend on the coach's ability to adapt the model creatively and the athlete's own capacity for interpretive expression. While the model succeeded in delivering a baseline standard, artistic excellence still varied due to individual and contextual factors.

The results of this study suggest that the implementation of choreographic models can help to standardise exercises, but flexibility in interpretation is also important to support the creativity of athletes. The results reinforce the idea that a combination of strong technical standards and room for individual creativity is key to the sustainable development of aerobic exercise.

The fact in the area of choreography displayed by athletes was not exactly the same as the model in the choreography video made by researchers to coaches at the Parent Board of Persatuan Senam Indonesia Regency, this proves that coaches have a variety of choreography, creativity, style, references, musicality, and different levels of difficulty according to the ability of athletes. The choreography model made video is a reference in determining the choreography pattern that will be displayed by athletes. Based on the value of the artistic evaluation, the elements of creativity and art can be categorised as follows

Table 7. List of Criteria for Artistic Value Based on the Results of Women's Individual Category Matches

No	Name	Artistic Value	Criteria
1	N1	5.3	Poor
2	N2	6.1	Statisfactory
3	N3	6.9	Statisfactory
4	N4	7.1	Good
5	N5	7.3	Good
6	N6	7.2	Good
7	N7	6.3	Statisfactory
8	N8	5.8	Poor
9	N9	5.3	Poor
Average		6.366	Statisfactory

Table 8. list of criteria for Artistic Value Based on the Results of Men's Individual Category Matches

No	Name	Artistic Value	Criteria
1	N1	7	Good
2	N2	5.6	Poor
3	N3	5.2	Poor
4	N4	5.2	Poor
Average		5.75	Poor

Tables 7 and 8 classify athletes into "Good," "Satisfactory," and "Poor" categories based on their artistic scores. Among 13 total athletes, only four (31%) reached the "Good" category, while six (46%) were rated "Poor." These results show that although the choreography video provided a standardized reference, individual creativity and artistic nuance varied significantly. This variability reflects the influence of the coach's interpretation, the athlete's musical sensitivity, and the complexity level adapted to individual capabilities.

The results of the study of the effectiveness of aerobic gymnastics choreography model in terms of creativity/artistic obtain average results in the criteria of good 4 athletes, statisfactory 3 athletes, poor 6 athletes. The results of the test of the effectiveness of aerobic gymnastics choreography model in terms of creativity / artistic get average results in the criteria of good 31%, the results show that the creativity of athletes is good in terms of aerobic content, general content, musicality, art and mastery of the stage. Statistical criteria 23%, the results show that the creativity of the athletes is satisfactory, but there are still deficiencies in terms of aerobic content and general content.

While p-values from the pretest-posttest comparison showed statistical significance ($p < 0.05$), the study lacks reporting of t-values, degrees of freedom (df), confidence intervals (CIs), and effect sizes (e.g., Cohen's d). These are crucial for interpreting the practical impact of the intervention. Including such metrics in future analyses would allow a better understanding of the magnitude of the choreography model's effect. Furthermore, the study's main dependent variables judges' scores are subjective and potentially prone to bias in the absence of blinding. The report does not specify whether judges were blinded to the pretest and posttest conditions, nor does it identify who the judges were or how scoring consistency was ensured. The absence of inter-rater reliability analysis also limits the robustness of conclusions.

Criteria poor 46%, the results show that the creativity of the athletes has not reached the expected standards, because in the execution of the performance is still often make mistakes in the movement of aerobic movement patterns, transitions and difficulty elements, which resulted in a reduction in value by the jury. The value of creativity is not the only value that became a benchmark in the performance of aerobic gymnastics, there is still a value of difficulty element and execution that became the evaluation material by the jury. Based on the

results of the above evaluation data, the researchers compared the results of the evaluation data before being given a choreography video guide with after being given a choreography video guide, namely; at the provincial championship in 2023 with the 2024 kejurprov, which was analysed by an effectiveness test using SPSS version 22. To test the effectiveness of aerobic gymnastics choreography model to improve the performance of student athletes in Central Java, researchers used paired t-test method with the following results;

Table 9. Results of the Statistical Effectiveness Test of Paired Samples

Pair 1	N	Correlation	Sig.
Pretest and Postest	42	.954	.000

Based on the table above, the results of the effectiveness test using paired t-tests showed the results of the p-value < 0.05. This means that the results of the test are significant. P value = 0.00. The results of the power test using paired t-test with p-value < 0.05 showed that the differences observed between the two conditions or two groups tested were statistically significant. This means that there is enough evidence to reject the null hypothesis that there is no real difference between the two conditions or groups. A value of p = 0.00 (or often called p < 0.001) indicates that the possibility of a difference occurring by chance or accident is very small.

Improving the adaptability of the coach can be applied to choreographic models, and the proposed framework includes several aspects. First, continuous training becomes a crucial element, with regular sessions based on FIG guidelines to deepen the trainer's understanding of artistic elements and choreographic techniques. Discussion and evaluation sessions in the form of forums involving coaches from different regions to exchange experiences and strategies for adapting choreographic models to the characteristics of athletes. The use of technology, such as video analysis, can also be an effective tool to evaluate the advantages and disadvantages of the choreography used, allowing the coach to make improvements objectively. It is also necessary to apply flexibility in the approach, encouraging the coach to adapt the choreography according to the athlete's abilities and potential, while respecting the basic principles established by the FIG. The servqual model for improving the quality of service based on research results includes reliability, which is achieved by providing consistent and evidence-based training programmes according to FIG guidelines, thus ensuring that each session delivers measurable and reliable results. Responsiveness is achieved through the organisation of regular discussion forums and the provision of rapid access to mentors or experts to help coaches adapt the choreography to the needs of the athletes. In terms of guarantees, the programme is supported by FIG-certified instructors who ensure that all the techniques taught are in line with international standards, thus increasing the confidence of the coach.

The empathy aspect is realised through an approach that takes into account the individual needs of coaches and athletes through by providing specialised counselling sessions and a supportive environment for skills development. Meanwhile, the physical evidence is strengthened through the provision of training materials in digital and printed form, as well as the use of technology such as video analysis to provide a more objective insight into choreographic performance.

The results of this study indicate that the video-based aerobic gymnastics choreography model has a significant impact on improving the performance of athletes, especially in the artistic and creative aspects of movement. Systematic choreographic instruction can improve the performance of aerobic athletes if video guidance or audio-visual media are used effectively as training aids (Martiani, 2019). The use of visual tools such as video guidance can improve athletes' understanding of movement details, improve motor memory, and speed up the process of movement adaptation (Choiriah & Hastuti, 2022; Sukamto et al., 2022).

These results are consistent with findings confirming that creativity in choreography plays an important role in improving the performance of athletes (Njaradi, 2024; Pakes, 2020a). Choreography rich with artistic elements can help athletes maximize their performance on stage, especially in aerobic gymnastics disciplines that combine art and physical techniques (Forcier, 2020; Pakes, 2020b). However, the study also showed differences in the ability of coaches to adapt choreographic models, which had an effect on the diversity of athletes' performance. This suggests that the effectiveness of training is determined not only by the given model, but also by the coach's ability to interpret and apply it in accordance with the capabilities of the athlete.

As an update, these findings emphasize the importance of flexibility in the use of choreographic models. Coaches need to innovate and adapt choreography based on the individual abilities of athletes, as reflected in the variety of artistic scores and execution among athletes. These findings reinforce the idea that coach creativity and training model adaptability are key factors in the development of athletes at different levels of competition (Lim, 2020; Petkovski, 2023; Vedel, 2020).

In addition to findings on improving athlete performance and creativity, there are several relevant findings related to training, athlete development, and innovation in sports learning methods. Video-based learning has a positive impact on athletes' understanding of complex movement patterns (Ashrafizadeh et al., 2023; Pitriani et al., 2022; Polechoński, 2024). The use of digital media in modern sports suggests that video as a learning tool can improve the technical and artistic performance of athletes (Farit et al., 2023; Rustan & Munawir, 2020; Anggra et al., 2021). Creativity in sports, especially in gymnastics, is an important element that can encourage innovation and uniqueness in the appearance of athletes (Gennaro, 2021; Mantillake, 2022; Risner, 2023).

Although the results show that choreographic models improve artistic aspects and creativity, the effectiveness of training also needs to be seen from the mastery of basic techniques and the execution of movements. Good choreography needs to be supported by solid mastery of technique in order to maximize performance (Cheng & Wang, 2024; George, 2022; Rustad, 2024).

CONCLUSION

This study shows that video-guided choreography can enhance the artistic and creative abilities of student athletes in aerobic gymnastics, especially in the Central Java context. While effective, the findings are limited to one province and discipline, restricting broader generalisation. To improve coaching, regional boards are advised to hold training workshops focused on integrating technology and adapting choreography to athlete needs. Future research should involve broader samples and disciplines, including longitudinal studies to assess long-term effects.

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