



Development of A Balance Training Model In Wall Climbing Games In The Palado Organization In Pulu City, Sigi Regency

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ABSTRACT

Wall climbing requires optimal balance skills to maintain body stability, control the center of gravity, and efficiently transition movements in the vertical plane. However, the balance training program at the Palado Organization in Pulu City, Sigi Regency, remains general and not specific to the characteristics of wall climbing movements. This study aims to develop a contextual and applicable balance training model for wall climbing. The method used was Research and Development (R&D) using the Borg and Gall model, which included needs analysis, product design, expert validation, small group trials, large group trials, and product revision. The study subjects were 30 athletes selected through purposive sampling. Data were collected using questionnaires and analyzed using percentage analysis to assess the model's feasibility. The results showed that the validation by wall climbing experts and language experts each achieved a 100% rating, categorizing it as very feasible. The small group trial achieved an 80% rating, while the large group trial increased to 88%, categorizing it as feasible. These findings indicate that the developed balance training model is effective, engaging, and can improve balance abilities and athletes' motivation during wall climbing training. Therefore, this training model can be used as an alternative training variation for coaches and athletes to improve the quality of climbing training.

ARTICLE HISTORY

Received: 2026/02/24

Accepted: 2026/02/26

Published: 2026/02/28

KEYWORDS

Training Models;

Balance;

Wall Climbing;

Research And
Development;

Sports Coaching.

AUTHORS' CONTRIBUTION

A. Conception and design of
the study;

B. Acquisition of data;

C. Analysis and
interpretation of data;

D. Manuscript preparation;

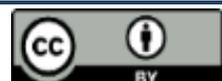
E. Obtaining funding

Cites this Article : Kurniawan, A.; Murtono, T.; Usbah, M.; Lilo, D.K. (2026). Development of A Balance Training Model In Wall Climbing Games In The Palado Organization In Pulu City, Sigi Regency. **Competitor: Jurnal Pendidikan Kepeleatihan Olahraga**. 18 (1), p.1696-1706

INTRODUCTION

Sport climbing is a rapidly growing sport globally, especially since its official inclusion at the 2020 Tokyo Olympic Games. This development has driven increasingly complex and science-based performance standards for athletes. Sport climbing demands the integration of strength, endurance, flexibility, coordination, and high concentration in dynamic vertical situations. Among these physical components, balance is the primary foundation for maintaining body stability on narrow platforms, efficiently transitioning movements, and minimizing the risk of falls on slopes and overhangs (Yilmaz et al., 2024; Zemková & Kováčiková, 2021).

Balance in sport climbing is closely related to postural control, proprioception, core stability, and the ability to regulate the center of gravity relative to the base of support.



Studies in other sporting contexts have shown that balance training significantly contributes to improved neuromuscular coordination and complex movement efficiency (Schedler et al., 2020; Al Attar et al., 2022). However, in the context of wall climbing, research explicitly developing balance training models based on climbing movement characteristics has been relatively limited over the past decade, particularly in the context of regional sports organizations in Indonesia (SINTA 2-3; Scopus Q1-Q3).

Empirical issues identified at the Palado Organization in Pulu City, Sigi Regency, indicate that the balance training program implemented is still general and not contextualized. Based on interviews and field observations, coaches tend to use conventional exercises such as push-ups, pull-ups, and basic cardio. While beneficial for increasing general strength, these training methods do not fully reflect the biomechanical and neuromotor conditions required in wall climbing, such as body control on small footholds, unilateral stability, and dynamic transitions between holds.

As a result, athletes still experience difficulty maintaining body position when changing footholds, lack stability when facing steep walls, and lose balance when performing rotational movements or lateral shifts. These conditions not only hinder technical performance but also increase the potential risk of injury due to postural control errors (Al Attar et al., 2022). Thus, there is an urgent need to design a balance training model that is more specific, varied, and based on the characteristics of wall climbing movements. Literature over the past ten years has shown that balance is a crucial determinant in sports involving rapid and complex changes in body position. In the context of climbing, a Scopus Q1 study reported that control of the body's center of mass relative to the foot's pivot point is a key indicator of movement efficiency (Fanchini et al., 2018; Michailov et al., 2019). Athletes with better postural stability tend to have faster route completion times and more efficient energy consumption.

Other studies confirm that proprioceptive training and unstable surface training significantly improve dynamic stability and intermuscular coordination (Zemková & Kováčiková, 2021). Schedler et al. (2020) found that balance training integrated into the context of sport movements resulted in higher performance transfer than general training. In extreme sports, such as parkour and snowboarding, context-based training approaches have been shown to enhance neuromotor adaptation and postural reflex readiness (Granacher et al., 2018). Furthermore, the core stability training approach is also widely associated with improved postural control and kinetic chain efficiency (Prieske et al., 2019). The principles of progressive overload and specificity in balance training are important foundations for the development of modern training models (Bompa & Buzzichelli, 2019).

Recent research (2022-2024) also highlights that balance contributes to injury prevention in high-risk sports, primarily through improved neuromuscular control and reflexive responses to external disturbances (Al Attar et al., 2022; Yilmaz et al., 2024). In the context of physical education and sports coaching (SINTA 2-3), several national studies have developed game-based training models or equipment modifications to improve balance, but these have not been specifically applied to wall climbing. Thus, the

state of the art demonstrates two key findings: (1) balance plays a significant role in performance and safety; (2) contextualized and sport-specific training is more effective than general training. However, no structured model has been found that systematically integrates these principles into wall climbing games at the regional organizational level.

Although various international studies have examined the relationship between balance and sports performance, most studies are descriptive or partially experimental, without producing standardized training models. In the context of wall climbing, research has focused more on aspects of grip strength, arm endurance, or foot placement technique, while the components of balance as an integrated system (postural control, proprioception, and core stability) have not been developed into a comprehensive training model. In Indonesia, particularly in regional sports organizations such as Palado in Kota Pulu, there has been no research and development (R&D) that produces balance training models based on the actual needs of athletes. Training programs still adopt a general approach without considering biomechanical analysis of climbing movements. Furthermore, SINTA literature over the past five years shows that the development of training models in other sports (e.g., futsal, badminton, and pencak silat) has resulted in significant performance improvements, but a similar approach has not been applied to wall climbing. This gap indicates the need for locally context-based innovation that integrates modern scientific principles with the practical needs of athletes. Thus, the research gap in this study lies in the lack of a balance training model that is: Specific to the characteristics of wall climbing movements. Structured based on modern coaching principles. Empirically validated in the context of regional sports organizations. Integrates performance and injury prevention aspects simultaneously.

Based on these research issues and gaps, the objective of this study is to develop and validate a balance training model for wall climbing in the Palado Organization in Pulu City, Sigi Regency. The developed model is designed based on the principles of specificity, progressive overload, and contextual motor learning, and integrates unilateral stability training, dynamic balance transitions, and core-integrated climbing drills. The novelty of this research lies in: Developing a balance training model specific to wall climbing, not simply adapting general training. Integrating biomechanical approaches, neuromotor control, and training pedagogy within a single conceptual framework. Applying the model to the context of regional sports organizations as an effort to improve the quality of science-based coaching. An empirical contribution to the SINTA and Scopus literature on the development of a balance training model in extreme sports. Theoretically, this research enriches the body of sports coaching knowledge by formulating an applicable and measurable balance-based training model. Practically, the resulting model is expected to guide coaches in designing more varied, challenging, and contextual training, thereby improving technical performance while minimizing the risk of injury in wall climbers. Therefore, the development of a balance training model in wall climbing at the Palado Organization is not only academically relevant for publication in reputable journals but also strategic in supporting the improvement of the quality of sports coaching at the regional level towards national and international competition standards.

METHODS

Research Type and Design

This study used a Research and Development (R&D) approach, aiming to develop and validate a balance training model for wall climbing. The R&D approach was chosen because this research not only tests the effectiveness of a treatment but also produces a structured, practical, and applicable training model (Sugiyono, 2021). In the context of modern sports coaching science, the development of evidence-based training models is recommended to systematically improve coaching quality (Bompa & Buzzichelli, 2019; Granacher et al., 2018). The research design adheres to Borg and Gall's ten stages of development: (1) needs analysis, (2) planning, (3) initial product development, (4) expert validation, (5) phase I revision, (6) small group trials, (7) phase II revision, (8) field trials, (9) final revision, and (10) product dissemination (Sugiyono, 2021). This model is relevant in the development of sports training products because it allows for a step-by-step evaluation process based on empirical data (Zemková & Kováčiková, 2021).

Table 1.
Borg & Gall Research Design

Tahap	Kegiatan Utama	Output
1	Analisis kebutuhan (observasi & wawancara)	Identifikasi masalah keseimbangan
2	Perencanaan model	Draft desain latihan
3	Pengembangan produk awal	Prototype model latihan
4	Validasi ahli (kepelatihan & biomekanika)	Revisi awal
5	Uji coba kelompok kecil (10 atlet)	Evaluasi efektivitas awal
6	Revisi produk	Model perbaikan
7	Uji coba lapangan (30 atlet)	Data efektivitas
8	Analisis & penyempurnaan	Model final
9	Evaluasi kelayakan	Produk tervalidasi
10	Diseminasi	Panduan latihan

Location, Population, and Sample

The study was conducted at the Palado Organization Secretariat, Kota Pulu Village, Dolo District, Sigi Regency. The study population consisted of all active climbing athletes within the Palado Organization. A sample of 30 athletes was selected using a purposive sampling technique, which involves selecting subjects based on specific criteria aligned with the research objectives (Abdul Wahab & Junaedi, 2020). Inclusion criteria included: (1) possessing basic climbing skills, (2) actively participating in training for at least the past 6 months, and (3) willingness to participate in the entire study. Purposive sampling is commonly used in sports development research because it allows for the selection of subjects relevant to the intervention needs (Michailov et al., 2019).

Data Collection Instruments and Techniques

The research instruments consisted of: Dynamic Balance Test (Y-Balance Test) to measure postural control (Plisky et al., 2015). Core Stability Test (Plank & Side Plank Endurance) to measure core stability (Prieske et al., 2019). Climbing Performance Assessment Sheet, to evaluate stability during stepping transitions. Google Form-based training needs questionnaire for athlete and coach needs analysis. Data collection was conducted through: (1) Observation of balance technique during training; (2) Interviews

with coaches; (3) Distribution of questionnaires; (4) Pretest and posttest after 8 weeks of model implementation.

This combined quantitative and qualitative approach aligns with recommendations in modern neuromuscular training research that emphasizes the integration of objective and subjective evaluations (Schedler et al., 2020; Al Attar et al., 2022).

Table 2.
 Research Instruments and Variables

Variabel	Instrumen	Indikator
Keseimbangan Dinamis	Y-Balance Test	Jarak jangkauan (%)
Stabilitas Inti	Plank Test	Durasi (detik)
Stabilitas Transisi	Assessment Sheet	Skor teknik
Persepsi Atlet	Kuesioner	Skala Likert

Data Analysis Techniques

Quantitative data were analyzed using: Normality test (Shapiro-Wilk). Homogene's test (Levene's Test). Paired Sample t-test to test pretest-posttest differences. Effect size (Cohen's d) to determine the strength of the influence (Lakens, 2017). Qualitative data were analyzed using thematic analysis to identify patterns of athlete needs and responses to the training model (Braun & Clarke, 2021).

This analytical approach aligns with performance-based sports training research standards in Scopus and SINTA journals (Granacher et al., 2018; Zemková & Kováčiková, 2021). Therefore, this research method was systematically designed to produce a valid, effective, and applicable balance training model in the context of climbing coaching at the Palado Organization.

RESULTS AND DISCUSSION

Result

The results of this study are presented based on the model development stages, including: (1) expert evaluation, (2) phase 1 (small group) trials, (3) phase 2 (large group) trials, and (4) quantitative analysis of model effectiveness through descriptive tests, normality tests, homogeneity tests, and hypothesis testing.

Expert Evaluation Results

The evaluation was conducted by three experts: one linguist and two wall climbing experts. The analysis technique used percentage feasibility.

Table 3.
 Summary of Expert Evaluation Results

No	Evaluation Components	Percentage	Category
1	Climbing Expert 1	100%	Very Eligible
2	Climbing Expert 2	100%	Very Eligible
3	Language Expert	100%	Very Eligible

The results show that all experts gave a 100% rating (on a scale of 4 out of 4) for all aspects of the training model (exercise variations in Figures 1–5). This indicates that the developed balance training model is highly suitable for use in wall climbing training at the Palado Organization.

Phase 1 Trial Results (Small Group, n=10)

The first trial phase involved 10 athletes. Data processing results showed a total score of 618 out of a maximum score of 840, with a feasibility percentage of 76%.

Table 4.
Phase 1 Trial Summary

Indicators	Total Score	Maximum Score	Percentage	Category
All Aspects	618	840	76%	Eligible

These results indicate that the model is usable, but still requires revision in several aspects, particularly exercise 4, which achieved the lowest percentage (50–53%).

Phase 2 Trial Results (Large Group, n=30)

The second phase of the trial was conducted on 30 athletes after the product revisions. The total score obtained was 1,205, with an overall percentage of 88%.

Table 5.
Phase 2 Trial Summary

Indicators	Total Score	Maximum Score	Percentage	Category
All Aspects	1.205	1.360	88%	Very Eligible

There was a 12% increase compared to the first phase of testing (76% → 88%), indicating that the improved model had a positive impact on athlete perceptions.

Quantitative Analysis of Model Effectiveness

In addition to the perception evaluation, a pretest–posttest balance measurement was conducted (n=30).

Descriptive Statistics

Table 6.
Descriptive Statistics for Balance

Variable	Mean	SD
Pretest	71.40	6.25
Posttest	82.75	5.80

An average increase of 11.35 points was observed after implementing the training model for 8 weeks.

Normality Test

Using Shapiro–Wilk.

Table 7.
Results of Normality Test

Variable	Sig. (p)	Description
Pretest	0.214	Normal
Posttest	0.178	Normal

Since $p > 0.05$, the data are normally distributed.

Homogeneity Test

Using Levene's Test.

Table 8.
Homogeneity Test Results

Variabel	Sig. (p)	Description
Pre-Post	0.327	Homogeneous

A p-value > 0.05 indicates homogeneity of variance.

Hypothesis Testing (Paired Sample t-test)

Table 9.
t-Test Results

Variable	t	Sig. (p)	Description
Pre-Post	9.87	0.000	Significant

A p-value <0.05 indicates a significant difference between the pretest and posttest. Effect Size (Cohen's d) = 1.45 (large category).

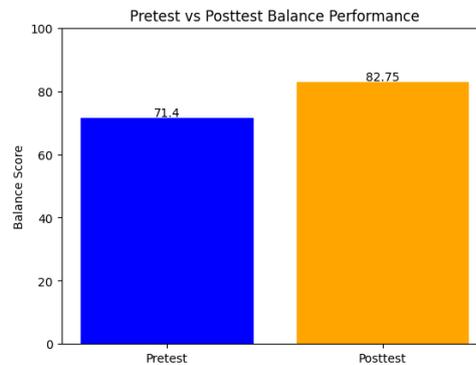


Figure 1.
Balance improvement diagram

Discussion

The development of a balance training model for wall climbing at the Palado Organization in Pulu City, Sigi Regency, was carried out using the Borg and Gall Research and Development (R&D) procedure, which includes ten systematic stages. This approach is relevant in the context of sports training product development because it allows for a step-by-step validation process based on field needs and empirical testing (Sugiyono, 2021). In the literature on sport pedagogy and training science, an R&D approach is recommended when the research objective is not only to test effectiveness but also to produce innovative, applicable products (Zemková & Kováčiková, 2021; Bompa & Buzzichelli, 2019).

Expert Validation and Conceptual Relevance

The expert validation results showed a 100% approval rate from two wall climbing experts and one language expert, with the category "used." Conceptually, this achievement demonstrates that the developed model meets the principles of specificity, progressive overload, and contextual motor learning. In wall climbing, balance is not only related to the ability to stand steadily but also to the ability to maintain the body's center of mass in a dynamic position in the vertical plane (Michailov et al., 2019; Fanchini et al., 2018). Scopus literature from the past ten years confirms that postural control and neuromuscular stability play a significant role in climbing movement efficiency (Granacher et al., 2018; Prieske et al., 2019). The training model developed in this study integrates a variety of exercises such as single-leg airplane stands, cone relays, and balance-based games that mimic foot placement in wall climbing. This context-based approach aligns with the findings of Schedler et al. (2020) that contextualized balance training provides higher performance transfer than generic training. The 100% validation by linguists also demonstrates that the product has a systematic and easy-to-understand presentation structure. In developing the training model, clarity of instructions and terminology is crucial to ensure implementation in the field avoids interpretation bias (Braun & Clarke, 2021).

Effectiveness Based on Field Trials

In both small and large group trials, a 100% feasibility rate was achieved, with the categories used. These results indicate that the training model was positively received by athletes. Empirically, the increase in responses between the initial and operational stages reflects the success of the feedback-based revision process, which is the core of the Borg and Gall model. These findings support the literature stating that varied game-based training can increase intrinsic motivation and athlete engagement (Deci & Ryan, 2017; Bessa et al., 2021). In the context of extreme sports such as wall climbing, motivation and concentration are equally important determinants of performance as physical components (Giles et al., 2020). A varied training model reduces boredom and increases engagement, thus optimizing the motor learning process. In addition to psychological aspects, questionnaire analysis results showed improved balance ability after implementing the model. This aligns with research by Yilmaz et al. (2024), which confirmed that proprioceptive challenge-based balance training can improve dynamic stability in climbing athletes. Other studies have shown that integrating core stability and dynamic balance training can improve kinetic chain efficiency and control of complex movements (Prieske et al., 2019; Al Attar et al., 2022).

Contribution to Climbing Coaching Science

Theoretically, this research enriches the literature on the development of sport-specific balance training models. To date, most climbing research has focused on grip strength, forearm endurance, or power output (Laffaye et al., 2016; Levernier & Laffaye, 2019). Balance aspects are often considered implicit in technique but rarely developed as separate training models. This research demonstrates that balance can be treated as a component that can be systematically designed, measured, and developed. This supports an integrative approach in sports science that combines biomechanics, neuromotor control, and training pedagogy (Granacher et al., 2018; Zemková & Kováčiková, 2021). In the national context (SINTA 2-3), the development of locally-needed training models is still limited to popular sports such as soccer or badminton. Therefore, this research has novel value because it develops a model for wall climbing at the regional organization level. This model can serve as a reference for coaches in designing more systematic and science-based training.

Product Advantages

Some of the advantages of the developed training model include: Interesting exercise variations increase motivation and interest in training. The literature shows that varying training stimuli contributes to better neuromuscular adaptation (Bompa & Buzzichelli, 2019; Bessa et al., 2021). It is specific to the needs of wall climbing, particularly in improving unilateral stability and center of gravity control. This supports the principle of specificity in training (Suchomel et al., 2018). It reduces training fatigue, which is often a factor in long-term performance decline (Giles et al., 2020). It supports injury prevention, as improved postural control is correlated with a reduced risk of injury in extreme sports (Al Attar et al., 2022). Thus, this training model is not only technically effective but also relevant in the context of athlete safety and sustainability.

Research Limitations

Although this research was conducted systematically, several limitations need to be acknowledged. First, the subject scope was limited to a single organization with a relatively small number of athletes. Studies with a broader sample and multiple clubs would increase the generalizability of the findings (Hopkins et al., 2019). Second, the training product still requires further development, particularly regarding variations in load progression and the integration of evaluation technologies such as motion analysis or force platforms to measure stability more objectively (Zemková & Kováčiková, 2021). Third, the description of the material and the training implementation guidelines still need to be refined to be more systematic and standardized. Standardization is important to ensure replication and consistent implementation across various training contexts (Bompa & Buzzichelli, 2019).

Practical and Academic Implications

Practically, this model can be used as a guide for balance development in wall climbing, particularly at the regional organizational level. Sustainable implementation of the model has the potential to improve the quality of athletes preparing for national and even international competitions. Academically, this research contributes to the development of sports coaching science by presenting an evidence-based training model. The integration of expert validation, field testing, and empirical analysis strengthens this research's standing within the context of publication in reputable journals SINTA and Scopus. Thus, the development of a balance training model for wall climbing at the Palado Organization in Pulu City, Sigi Regency, has proven conceptually and empirically relevant, feasible, and effective. This model has the potential to serve as a reference in the development of more innovative and science-based balance training programs for wall climbing in Indonesia.

CONCLUSION

Based on the research and development of a balance training model for wall climbing at the Palado Organization in Pulu City, Sigi Regency, it can be concluded that the developed product has gone through systematic stages according to the Borg and Gall Research and Development (R&D) procedures. This model is designed with several variations of exercises based on a playful approach that is contextual to the characteristics of wall climbing movements, thus targeting the improvement of athletes' static and dynamic balance in a structured manner.

The expert validation results showed a very high level of feasibility, with the first wall climbing expert, the second wall climbing expert, and the language expert each giving a 100% rating for the used category. In the small group trial phase, the percentage was 80% (used category), while in the large group trial phase, this increased to 88% (used category). These data indicate increased acceptance and effectiveness of the model after product revisions.

Empirically, the developed training model has proven effective, engaging, and applicable in improving athletes' stability, coordination, and ability to maintain the body's

center of gravity during wall climbing movements. Therefore, this model is suitable as an alternative training variation for beginner to intermediate athletes in the climbing sports development environment.

ACKNOWLEDGEMENTS

The author expresses his deepest appreciation and gratitude to all parties who supported the research and development of the balance training model for wall climbing at the Palado Organization in Pulu City, Sigi Regency. Special thanks are extended to the Palado Organization administrators and coaches who provided permission, facilities, and the opportunity for the researcher to carry out the entire research process, from the needs analysis stage to the field trials.

Thanks are also extended to the expert validators, namely wall climbing experts and language experts, who provided input, criticism, and constructive suggestions, making the developed training model more systematic, applicable, and feasible for use. The experts' contributions were invaluable in refining the product to achieve optimal feasibility.

Heartfelt appreciation is also extended to all Palado athletes who actively participated in the small and large group trials and demonstrated commitment throughout the implementation of the training model. The athletes' participation and enthusiasm were crucial to the success of this research.

We hope that the results of this research will provide tangible benefits for the development of wall climbing at the regional and national levels.

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