Validación y fiabilidad de un programa de ejercicios de visualización y relajación para mejorar el rendimiento en escalada de velocidad

Validation and reliability of a visualization and relaxation exercise program for enhancing speed climbing performance

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Abstract

Introduction and Objective: This study aimed to design, validate, and evaluate the reliability of a visualization and relaxation exercise program to improve speed climbing performance. While it may seem less popular, these techniques are crucial for creating more focus in the mind, decreasing anxiety, and improving motor skills in high-intensity sports.
Methodology: In this research, a mixed-method research design was used with 30 athletes aged 18 – 35 from Yogyakarta state with a minimum of two years of climbing experience. Expert evaluations, observer training, and reliability testing were used in the validation process. Movement skill, power, balance, speed, timing, and tactical acumen are the criteria for assessment.
Results: Aiken's V index scores (≥ 0.86) confirmed that the research instrument has content validity with strong agreement between the experts. High consistency was also reflected by observer reliability metrics, such as Cohen's Kappa (≥ 0.86) and Kendall's Tau B. The generalizability analysis of the instrument reinforced its accuracy and precision in measuring program impact.
Conclusions: The manufactured program gives coaches and researchers a way of structuring mental training to improve speed climbing performance in a reliable framework. Its robust nature facilitates reliable measurement of athletes' technical, tactical, and psychological attributes and, thus, the development of more effective training interventions. Additional research suggests utilizing this tool with diverse, larger populations and expanding the application to other precision-based sports.

Keywords

Validation, Reliability, Instrument, Observation, Rock Climbing, Technical Analysis

Resumen

Introducción y Objetivo: Este estudio tuvo como objetivo diseñar, validar y evaluar la fiabilidad de un programa de ejercicios de visualización y relajación para mejorar el rendimiento en escalada de velocidad. Aunque puede parecer menos común, estas técnicas son esenciales para crear mayor concentración mental, disminuir la ansiedad y mejorar las habilidades motoras en deportes de alta intensidad.
Metodología: En esta investigación se utilizó un diseño de investigación de métodos mixtos con 30 atletas de entre 18 y 35 años del estado de Yogyakarta, con un mínimo de dos años de experiencia en escalada. El proceso de validación incluyó evaluaciones de expertos, entrenamiento de observadores y pruebas de fiabilidad. Los criterios de evaluación incluyeron habilidades de movimiento, potencia, equilibrio, velocidad, sincronización y destreza táctica.
Resultados: Los puntajes del índice V de Aiken (≥ 0.86) confirmaron que el instrumento de investigación tiene validez de contenido con un fuerte acuerdo entre los expertos. La alta consistencia también se reflejó en las métricas de fiabilidad del observador, como el Kappa de Cohen (≥ 0.86) y el Tau B de Kendall. El análisis de generalizabilidad del instrumento reforzó su precisión y exactitud en la medición del impacto del programa.
Conclusiones: El programa desarrollado proporciona a entrenadores e investigadores una forma estructurada de entrenamiento mental para mejorar el rendimiento en escalada de velocidad dentro de un marco fiable. Su naturaleza robusta facilita la medición fiable de los atributos técnicos, tácticos y psicológicos de los atletas, promoviendo el desarrollo de intervenciones de entrenamiento más efectivas. Se recomienda investigación adicional para aplicar esta herramienta en poblaciones más diversas y numerosas, y expandir su uso a otros deportes de precisión.

Palabras clave

Validación, Fiabilidad, Instrumento, Observación, Escalada en Roca, Análisis Técnico.

Introduction

In competitive sports, visualization and relaxation techniques are widely recognized for their ability to improve mental focus, reduce pre-performance anxiety, and refine motor skills (Corrado et al., 2024; Pelka et al., 2016) on visualization; (Firănescu et al., 2020) and on relaxation (Ilham & Dimyati, 2021). In the context of speed climbing, where precision and quick reactions are crucial, these techniques could give athletes an edge by allowing them to handle stress better and maintain concentration during high-intensity efforts.

A focused literature review on visualization and relaxation in sports with similar demands, such as gymnastics (Chiat et al., 2022) or sprinting, may offer insights into the potential effectiveness of these methods for speed climbing. (Trifu et al., 2021) Existing research in these sports shows that mental training can enhance athletes' reaction times, spatial awareness, and ability to manage pressure—skills directly transferable to competitive climbing (Ivanova, 2019; Krawczyk et al., 2019; Sanz et al., 2015). Rock climbing has emerged as an Olympic sport that requires high levels of power, speed, strength, and endurance, with athletes competing to achieve the fastest times. Existing studies have analyzed cognitive processes during competition in various sports contexts (Castells-Sánchez et al., 2021; Dimyati et al., 2023). The physical and psychological profile required for rock climbing involves technical, tactical and cognitive abilities, motor skills, mental resilience, strength, endurance, speed, agility, and coordination.

For sports like soccer, match analysis deals with individual and team actions. In particular, it sheds light on managers' and opponents' strengths and weaknesses to facilitate the training and preparation for the game (Markati et al., 2019). All sports, however, have unique traits such as rules, playing area, team size, and substitution options, which lead to different athletes' stress and physical load profiles. Unlike soccer or other team sports, rock climbing is an individual, precision-based sport, demanding tactical and technical precision. Coaches can employ various strategies to influence performance, but accurately assessing the factors that impact performance in climbing is complex due to its combination of diverse movements like running, jumping, pushing, and direction changes (Seifert et al., 2017). Analyzing factors that impact performance in rock climbing is challenging because this sport combines multiple elements, including coordination for activities such as running, jumping, pushing, and changing direction. Intensity levels fluctuate continuously throughout a match, varying from standing or walking to jogging, sprinting, and quick directional shifts. Rock climbing events such as bouldering, lead climbing, and speed climbing require different skills and physical attributes, with each discipline emphasizing distinct aspects like agility, explosive power, and endurance (Garrido-Palomino et al., 2020; David Giles et al., 2014). The differentiated demands of these styles contribute to the sport's complexity, making rock climbing an intense and multifaceted discipline that presents unique challenges for athletes.

Research shows that performance in rock climbing is influenced by maximal angular velocity in the pelvis, trunk, and shoulder's internal rotation, which is essential for effective movement (D. Giles & Draper, 2018; Sukarmin et al., 2021). Frequent, multidirectional changes are typical in climbing, with athletes performing rapid stop-and-go movements in response to unpredictable stimuli, often on small and narrow surfaces (Guo et al., 2019). The acyclic sequence of high-intensity efforts characteristic of speed climbing, including dynamic accelerations, short maximal sprints, and quick directional shifts, demands a comprehensive, sport-specific analysis. This complexity in rock climbing necessitates a comprehensive and detailed analysis of its specific attributes. With in-depth knowledge of these unique characteristics, achieving accurate performance diagnostics tailored to the sport's demands is easier. Rock climbing is mainly characterized by an acyclic sequence of high-intensity phases, including dynamic accelerations, short maximal sprints, and rapid directional changes. With in-depth knowledge of these unique attributes, conducting accurate performance diagnostics tailored to rock climbing's demands becomes easier. Thus, more targeted research is needed to identify and validate methods that can enhance the technical and psychological aspects of performance in competitive rock climbing.

The purpose of this study was to investigate the validity and reliability of a program of visualization and relaxation exercises tailored to enhance performance in the speed climbing world record category. Because mental training has always been a focus of Olympic sports, developing a scientifically validated program designed for the speed-climbing athlete is essential. Even though visualization and relaxation

are important, research is needed to understand how the construction of such programs relates to their validity and reliability and how such programs can improve performance in speed climbing.

Method

Research Design

The design of the observational instrument was a nomothetic, follow-up and multidimensional design (Anguera & Hernández-Mendo, 2013). The approach developed here combines nomothetic and dimensional aspects to encompass the full richness of behavioural phenomena. Using a mixed approach that includes field formats and categorical systems, the observation tool provided a multidimensional, cross-sectional framework suitable for applications in sports observation studies. The final instrument comprised six main criteria and 60 categorical cores optimized for generalizability and relevance to capture critical gameplay elements. An illustrative exercise was to have athletes visualize their climbing route by mentally running through their hold and movements—without letting their mind drift off—and detaching themselves from distractions and anxiety-producing thoughts.

Participants

The sample study covered 30 speed-climbing athletes aged 18 to 35 who had at least two years of climbing experience and followed the requirements of the study sample to guarantee replicability and relevance. Baseline consistency was maintained by excluding participants with prior exposure to structured mental training.

Instrument

The instrument measured six categories of observational criteria, including movement skill, power, balance, speed, timing, and tactical acumen. Complex movements, such as jumps, turns, slides and blocking techniques, were assessed. The fifth pointed at technical skill combined with tactical efficiency, i.e., fighting skill woven with strategy, and possessing operational speed, i.e., integrating physical power with strategy. The sixth concern looked at technical-tactical actions: players' organization with climbing structures and adaptation to objects in the climbing environment. We imposed this categorical division, intended to be exhaustive, mutually exclusive, and amenable to fine-grained analysis of each category.

Procedure

The instrument's design and validation process involved four main stages. To identify pertinent psychological training methodologies, an extensive literature review was initially conducted across various databases (e.g., Web of Science, Scopus, Sports Discus, Google Scholar). Key search terms included “climbing,” “visualization,” and “relaxation,” guiding the development of initial categorical cores and openness degrees.

The criteria, categorical cores, and behavioural definitions underwent expert validation in the second stage. Content validity was assessed by a panel of ten experts, consisting of seven PhD holders in physical education and three experienced coaches. Using the Delphi method, the experts provided quantitative scores on clarity and relevance (0–10 scale) and qualitative feedback. Specifically, the experts suggested improving the categorical framework by proposing new categories or refining existing degrees of openness.

Content validity was measured using Aiken's V index, which allowed us to assess the degree of expert agreement on key criteria and, therefore, reinforced the instrument's reliability (Aiken, 1985). Content validity was measured by Aiken's V index, which determines the degree of agreement among experts on the key criteria and ultimately results in the instrument's reliability (Aiken, 1985). Confidence intervals at 90%, 95%, and 99% were set as benchmarks, following established scoring methods. Items with average ratings below 0.70 were eliminated, while those scoring between 0.70 and 0.80 underwent revision based on expert insights. Items achieving scores above 0.80 remained unaltered (Hsu & Sandford, 2007).

In the third stage, reliability was tested through observer training and a reliability assessment session. Observers experienced in sports science and psychology participated in match analyses led by an expert

observer. Cohen's Kappa, intraclass correlation (ICC), and Kendall's Tau B coefficients were employed to evaluate inter- and intra-observer consistency, confirming the instrument's reliability. Data analysis was performed with SPSS 24.0, while generalizability testing was conducted using SGAT software (Reigal et al., 2019).

Data analysis

The final observational instrument included a comprehensive list of categorical cores and degrees of openness supported by rigorous expert validation. Table 1 presents content validity values (Aiken's V), indicating strong agreement across core categories and relevance indicators.

Results

The final observational instrument included a comprehensive list of categorical cores and degrees of openness supported by rigorous expert validation. Table 1 displays content validity values (Aiken's V), demonstrating high agreement levels across categorical cores and relevance indicators.

Table 1. Values of Content Validity (Aiken's V)

Variable	Indicators	Average Score	Aiken Score
Exercise Program	Disassociated Visualization		
	The introduction to the program is eligible for a Disassociated Visualization mental training program.	4	0.89
	Motivate athletes to focus on a given exercise.	3.98	0.98
	The editorial foreword to the training program is effective, making it easily understood by coaches and athletes.	4	0.95
	Visualization training in the program is tailored to improve the performance of speed-climbing athletes.	3.85	0.96
	Usefulness of Practice		
	Directing athletes to take responsibility for following the training to enhance performance.	4	0.98
	Encouraging athletes to set goals for visualization exercises.	4	0.92
	Target Practice		
	The program's target audience for the Disassociated Visualization training is speed-climbing athletes aged 15-20.	3.97	0.88
	Series of Implementation of the Training Program		
	The program's wording is grammatically appropriate, clear, concise, complete, constructive, and easy to understand.	4	0.94
	The implementation of the Disassociated Visualization training program aligns to enhance athlete performance in speed climbing.	3.87	0.97
	Athletes are informed about their roles in the visualization training process.	3.95	0.96
	Verbal communication is emphasized consistently, clearly, and specifically throughout the training process.	3.92	0.91
	The program's text is grammatically accurate, concise, complete, and constructive, ensuring easy comprehension.	3.87	0.93
	The disassociated visualization exercises provided are aligned with the construct of disassociated visualization training, being clear, concise, complete, and constructive.	3.96	0.97
	Substance		
	An adequate number of practice meetings were held.	3.94	0.98
	Adequacy of the duration of the given visualization exercise.	4	0.90
	Conducting training and control evaluations.	4	0.94

Table 1 illustrates how qualitative and quantitative expert evaluations, combined with Aiken's V, facilitated the measurement of content validity across various items. The quantitative evaluations were consistently high for all categorical cores (Vo ≥ 0.70), surpassing the minimum threshold proposed in the literature (Vo = 0.70).

The qualitative evaluations clarified certain definitions, particularly the degrees of openness within the categorical cores. The inclusion of experts from both research and coaching backgrounds ensured a more comprehensive and holistic understanding of the sport.

The level of intra-observer reliability, as assessed between observers following the training, confirmed that the instrument is reliable. The well-established categorical cores, degrees of openness in the field, and expert qualitative evaluations contributed to the instrument's high reliability. Moreover, the results from the generalizability analysis reinforced the instrument's high validity and precision, further supporting the observers' high-reliability indices.

The data obtained through this instrument offers valuable insights for coaches, enabling them to better understand game patterns, respond effectively to competition, and design targeted training sessions.

The instrument's structure allows coaches and researchers to stratify training, identifying the strengths and weaknesses of athletes with precision.

Table 2. Intra- and Inter-Observer Reliability Metrics for Observational Instrument Criteria

Criteria and Categorical Cores	Intra-reliability Kappa/ICC	Inter-reliability Kappa/ICC	Intra-reliability Kendall's Tau B	Inter-reliability Kendall's Tau B
1. The introduction to the program is eligible for a Disassociated Visualization mental training program	0.87	0.96	0.88	0.89
2. Motivate athletes to focus on a given exercise	0.88	0.89	0.93	0.94
3. Editorial foreword to the training program has been effective so that it is easily understood by coaches and athletes	0.95	0.97	0.95	0.94
4. The use of Visualization training in the training program is made according to the goal, namely, improving the performance of Speed climbing athletes	0.98	0.96	0.97	0.94
5. Directing athletes to have a sense of responsibility to follow the training given to improve performance	0.95	0.98	0.89	0.90
6. Encourage athletes to set goals for visualization exercises	0.93	0.97	0.86	0.88
7. The target of the Disassociated Visualization training in the training program that is made is by the target, namely, the speed of speed climbing athlete who is 15-20 years old	0.87	0.88	0.88	0.86
8. Editors of words are grammatically appropriate, clear, concise, complete, constructive, and easy to understand	0.86	0.90	0.94	0.87
9. The series of implementation of the Disassociated Visualization training program is by the goal, namely, improving the performance of athletes with speed climbing	0.89	0.92	0.96	0.94
10. Make athletes know what to do in the visualization training process that will be given	0.93	0.91	0.96	0.93
11. Verbal communication is more emphasized in the training process, consistently, clearly, and specifically	0.97	0.87	0.88	0.94
12. Editors of words are grammatically appropriate, clear, concise, complete, constructive, and easy to understand	0.96	0.88	0.93	0.96
13. The disassociated visualization exercise provided includes exercises according to the construct of the disassociated visualization exercise, clear, concise, complete, and constructive	0.86	0.97	0.92	0.90
14. Adequate number of practice meetings held	0.89	0.96	0.90	0.92
15. Adequacy of the duration of the given visualization exercise	0.88	0.94	0.94	0.91
16. Conduct training and control evaluations	0.93	0.87	0.97	0.96

Table 2 illustrates the intra- and inter-observer agreement on multiple criteria within the observational instrument, assessed through Cohen's Kappa, the Intraclass Correlation Coefficient (ICC), and Kendall's Tau B. These metrics are critical for evaluating the consistency of observations across trained observers and support the instrument's validity in a structured mental training program.

The intra-observer reliability metrics, which indicate an observer's consistency across repeated assessments, exhibit robust scores, with Kappa/ICC values ranging from 0.86 to 0.98 across all criteria. For instance, the criterion "Directing athletes to have a sense of responsibility to follow the training" yields high intra-observer reliability values (Kappa = 0.95, ICC = 0.98), suggesting that individual observers apply the criteria consistently over time. These strong intra-observer scores underscore the clarity and specificity of the instrument's definitions, enabling individual observers to maintain high accuracy across sessions.

Inter-observer reliability scores (i.e. agreement between different observers) are always high, with most Kappa/ICC scores > 0.88. These values suggest how accurate the instrument is in providing similar outcomes among different observers, confirming the applicability of the same in the context of multiple assessors. For example, the criterion 'Use of Visualization training to improve speed climbing athlete performance' exhibited an inter-observer reliability of 0.96 relative to both Kappa and ICC. High scores for these tools indicate that observers share the criteria of the instrument, which is a prerequisite for collaborative or cross-context assessment.

Kendall's Tau B coefficients further validate these findings by demonstrating high ordinal agreement across criteria, with values generally above 0.85 for intra- and inter-observer reliability. Kendall's Tau B is particularly valuable in confirming the ordinal reliability of observer ratings, showing that the observers rank the criteria consistently across observations. For example, the criterion "Encourage athletes to set goals for visualization exercises" presents a Kendall's Tau B value of 0.86 for intra-reliability and 0.88 for inter-reliability, suggesting stable ordinal consistency.

In summary, the high levels of agreement across Cohen's Kappa, ICC, and Kendall's Tau B metrics demonstrate the observational instrument's reliability in individual and group settings. These findings confirm that the instrument facilitates consistent, replicable measurements of mental training program components, reinforcing its potential utility for structured assessments in athletic contexts. Such reliability ensures that the instrument can be effectively applied in research and practice, supporting the integrity of the data collected and the subsequent analyses.

Discussion

This study contributes to the body of knowledge on speed climbing by presenting a validated and reliable observational instrument designed to evaluate the impact of a structured visualization and relaxation exercise program on athletic performance. Developed to combine qualitative and quantitative analysis through expert feedback and statistical validation, the tool's development meaningfully incorporates the technical, tactical, and psychological aspects important for competitive climbing. The findings indicate that this instrument holds significant potential for researchers and coaches to improve speed-climbing performance by integrating mental training strategies.

High values for content validity values of Aiken's V index of higher than 0.86 show that the instrument design truly captures all the essential features of speed climbing. The six main criteria (movement skill, power, balance, speed, timing and tactical acumen) allowed for a holistic athlete performance assessment equally focused on mental focus and physical execution. Finally, expert evaluations confirmed the relevance and clarity of each criterion, and they showed that the tool fit the practical needs of researchers and coaches well. The instrument's alignment reflects its applicability in a professional setting, in which real, real-time assessment of an athlete's mental and physical readiness is crucial (Aiken, 1985; Hsu & Sandford, 2007).

The study confirmed the reliability of the observational tool, as demonstrated by high intra- and inter-observer reliability scores. The consistent results across Cohen's Kappa, intraclass correlation (ICC), and Kendall's Tau B coefficients—predominantly above 0.88—highlight that observers could consistently apply the instrument's criteria over repeated assessments. These findings indicate that the instrument contributes to a consistent basis to assess the effects of mental training interventions. As such, results may be repeated reliably in research and training environments (Reigal et al., 2019). The instrument's design also supports the argument of its robustness by being adaptable across different types of observers, which is manifested in a high inter-observer agreement. This suggests that the tool is suitable for collaborative or multi-coach settings, where shared understandings of performance indicators are necessary for uniform assessment and feedback. Notably, the instrument's reliability reinforces its value in creating structured mental training assessments for athletic contexts, where high levels of precision and accuracy in observation are required (Ilham & Tomoliyus, 2021).

The findings of this study underline the importance of mental training programs that integrate visualization and relaxation techniques in speed climbing. Visualization helps athletes mentally rehearse complex routes, enhancing spatial awareness and anticipatory skills essential for high-level performance (Firănescu et al., 2020; Ilham & Dimyati, 2021). By combining visualization with relaxation, athletes are better equipped to manage stress and maintain concentration during the intense physical demands of climbing, aligning with previous research on the benefits of mental training for motor performance and anxiety reduction in competitive sports (Pelka et al., 2016; Sanz et al., 2015). This instrument will serve as a structured approach for coaches to utilize in evaluating and putting to use mental training interventions, as well as to quantify and monitor progress in psychological attributes that influence performance. For example, the tool helps coaches monitor performance gains in mental focus, self-regulation, and stress tolerance, all necessary to execute high-stakes movements under pressure. Furthermore, the open-category frameworks of the instrument permit a more in-depth analysis of athlete behaviour, with finer-grained data points that are not captured by closed-category models (Ortega Toro et al., 2019).

Observational tools in sports such as soccer and basketball typically focus on tactical and technical performance indicators. However, these tools often rely on predefined, closed categories that may restrict observation scope and limit the depth of analysis (Hernández et al., 2014; Ortega-Toro et al.,

2019). In contrast, the current study's instrument embraces open categories, allowing for richer and more continuous analysis. This approach is particularly valuable in speed climbing, where individual skill, mental resilience, and technical precision play equally important roles in overall performance (Seifert et al., 2017; Sukarmin et al., 2021).

The six categorical cores—from technique to tactical elements—align closely with similar frameworks in sports, requiring rapid decision-making and high motor coordination. The study offers a tool that takes these generalizable categories of speed climbing's unique climbing demands and applies them to the complexities of speed climbing, allowing for comparisons to other precision-oriented sports. The instrument may be valuable to coaches of these sports as a template for developing mental training assessments that consider sport-specific nuances (Castells-Sánchez et al., 2021).

This study demonstrates a robust observational tool; however, it has limitations. Expert evaluations were the main method used for validation, which is valuable but, in general, could benefit from further field testing in a more general competitive setting. Due to the small sample size of only 30 athletes, the findings of this study are not generalizable to larger and more diverse climbing populations. Further research should use larger sample sizes and different capabilities in athletics to confirm its reliability and versatility. Another limitation is that the tool, in its current state, is primarily aimed at tackling technical and tactical aspects of performance rather than psychological or physiological factors influencing performance. It could complement the existing battery of tests to assess physical readiness to compete, returning sports to a more holistic approach by integrating measures of emotional resilience, physiological stress response and fatigue management. The tool could also be used as a comparison to other sports wherein similar demands in mental focus and rapid motor coordination (e.g., gymnastics, sprinting) exist.

Value added to the field is provided by the framework of this observational instrument, which offers a rigorous, easy-to-implement framework for assessing whether mental training impacts performance athlete' stool captures detailed data of an athlete's behaviour and decision-making under pressure, allowing coaches to learn where specific improvements can be made, and offering a more focused, personalized training plan. By integrating evidence-based training modalities and drawing parallels to performance-enhancing modalities considered legal in elite sports, this approach can ultimately augment athlete performance and provide a practical resource to coaches looking to add mental training techniques in preparation for high-level competition.).

Conclusions

The findings of this study indicate that the developed observational instrument is both valid and reliable for assessing the impact of a structured visualization and relaxation program on speed-climbing performance. The tool exhibits high content validity and reliably obtains valuable performance indicators in speed climbing with high inter and intra-observer reliability. The instrument allows coaches to apply the insights in developing training interventions by focusing on essential player attributes like movement skill, power, balance, speed, timing, and tactical. This allows athletes to train through better mental focus performance skills and motor refinement in competitive conditions. However, additional research is recommended to validate the instrument with more extensive and diverse samples and in other sports settings to increase the instrument's generalizability. A holistic performance assessment, practical for high-intensity, precision-based sports, may also be achieved by integrating psychological and physiological measures. Thus, this study provides a flexible, reliable tool for evidence-based coaching applicable to speed climbing, closes the gap between mental training and performance testing regarding technical performance, and offers an avenue for refining climbing performance enhancement strategies.

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