

Knowledge of Neurobic Exercise and Cognitive Benefits Among Sports Science Students in Indonesia

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Received: 2024-03-18

Accepted: 2024-06-25

Published: 2024-09-12

Abstract. Understanding neurobic exercise and its potential cognitive benefits is essential for sports science students, particularly in integrating cognitive and motor training into physical activity programs. However, information regarding students' knowledge of neurobic exercise remains limited. This study aimed to assess the level of knowledge among Sports Science students at Universitas Negeri Semarang regarding neurobic exercise and its potential effects on cognitive function. A quantitative descriptive design using a survey method was employed. Fifty-six students were recruited through purposive sampling based on predetermined eligibility criteria. Data were collected using a 30-item questionnaire covering three indicators: fundamental knowledge of neurobic exercise, understanding of cognitive functions, and knowledge of the relationship between neurobic exercise and cognitive improvement. Descriptive statistical analysis revealed that 45 students (80.36%) demonstrated good knowledge, while 11 students (19.64%) exhibited moderate knowledge. The mean knowledge score was 22.9 ± 2.47 , ranging from 17 to 28. Although overall knowledge was categorized as good, understanding of cognitive functions remained predominantly moderate. These findings highlight the importance of strengthening cognitive science education within sports science curricula to support evidence-based training practices.

Key words: cognitive function; knowledge assessment; neurobic exercise; sports science students

Abstract in Indonesia. Pemahaman mengenai latihan neurobik (*neurobic exercise*) dan potensi manfaatnya terhadap fungsi kognitif merupakan aspek penting bagi mahasiswa ilmu keolahragaan, khususnya dalam mengintegrasikan latihan motorik dan kognitif ke dalam program aktivitas fisik. Namun, kajian mengenai tingkat pengetahuan mahasiswa terhadap latihan neurobik masih terbatas. Penelitian ini bertujuan untuk mengetahui tingkat pengetahuan mahasiswa Ilmu Keolahragaan Universitas Negeri Semarang mengenai latihan neurobik dan pengaruhnya terhadap peningkatan fungsi kognitif. Penelitian menggunakan pendekatan deskriptif kuantitatif dengan metode survei. Sebanyak 56 mahasiswa dipilih menggunakan teknik *purposive sampling* berdasarkan kriteria yang telah ditentukan. Pengumpulan data dilakukan menggunakan kuesioner yang terdiri atas 30 butir pertanyaan dengan tiga indikator, yaitu pengetahuan dasar latihan neurobik, pemahaman aspek kognitif, serta hubungan latihan neurobik dengan peningkatan fungsi kognitif. Analisis data menggunakan statistik deskriptif. Hasil penelitian menunjukkan bahwa 45 mahasiswa (80,36%) memiliki tingkat pengetahuan baik, sedangkan 11 mahasiswa (19,64%) memiliki tingkat pengetahuan sedang. Rata-rata skor pengetahuan sebesar 22,9 dengan simpangan baku 2,47, serta rentang skor 17–28. Meskipun tingkat pengetahuan secara keseluruhan tergolong baik, pemahaman mengenai aspek kognitif masih didominasi kategori sedang. Temuan ini menunjukkan pentingnya penguatan pemahaman fungsi kognitif dalam pembelajaran ilmu keolahragaan.

Kata Kunci: fungsi kognitif; latihan neurobik; mahasiswa ilmu keolahragaan; tingkat pengetahuan

How to Cite: Alfauzani, M. R., & Setiowati, A. (2024). Knowledge of Neurobic Exercise and Cognitive Benefits Among Sports Science Students in Indonesia. *MIKI: Media Ilmu Keolahragaan Indonesia* 14 (2), 87-100.

DOI: <http://dx.doi.org/10.15294/miki.v14i2.11738>

INTRODUCTION

Cognitive function plays an essential role in human performance, particularly in activities requiring attention, memory, decision-making, and motor coordination. In sports science, cognitive abilities contribute to the execution of complex movements, the interpretation of environmental information, and the regulation of behavioral responses during physical activity. Athletes and physically active individuals frequently encounter situations requiring rapid information processing, sustained concentration, and appropriate decisions under changing environmental conditions. Consequently, cognitive performance has become an important consideration in developing comprehensive physical training programs. Singh et al. (2025), through a systematic umbrella review involving 2,724 randomized controlled trials, demonstrated that physical exercise contributes to improvements in general cognition, memory, and executive function. These findings emphasize the importance of understanding

how physical activity interacts with cognitive processes and provide a scientific foundation for integrating cognitive components into exercise programs.

Recent developments in exercise science have increased interest in training approaches that simultaneously engage physical movement and cognitive processing. Unlike conventional exercise programs primarily emphasizing physiological adaptations, cognitively engaging exercise incorporates tasks involving attention, working memory, coordination, and decision-making. Ludyga et al. (2023) demonstrated that exercise involving coordinative demands can improve executive functions, particularly inhibitory control and working memory, among young and middle-aged adults. Their network meta-analysis also indicated that combining physical exercise with cognitive training may produce greater improvements in certain cognitive outcomes than individual training approaches. Similarly, Garrett et al. (2024) reported that acute physical activity produced small but measurable improvements in cognitive performance among healthy young adults. These findings suggest that integrating physical and cognitive challenges represents a potentially valuable approach to exercise programming, particularly for individuals whose academic and professional activities require cognitive efficiency.

One training approach associated with cognitive stimulation is neurobic exercise, which emphasizes unfamiliar experiences, sensory engagement, and modifications of habitual activities. Neurobic exercise encourages individuals to perform activities that challenge established behavioral patterns by introducing novel sensory or motor experiences. Such activities may involve using the nondominant hand, modifying familiar movement sequences, or combining motor coordination with attention-demanding tasks. Katz and Rubin (2014) described neurobic exercise as an approach designed to stimulate mental activity through everyday experiences involving multiple senses and unfamiliar challenges. Although neurobic exercise shares certain characteristics with cognitive-motor and multimodal training, these approaches should not be considered identical. Neurobic activities generally emphasize novelty and sensory stimulation, whereas structured cognitive-motor interventions may incorporate specific physical and cognitive training protocols. Understanding these distinctions is necessary for interpreting the potential benefits and limitations of neurobic exercise within sports science.

The scientific rationale for integrating cognitive and motor activities is partly associated with the adaptive capacity of the nervous system. Neural plasticity refers to the ability of the nervous system to modify its functional organization in response to experience, learning, and repeated stimulation. Demirakca et al. (2016) investigated changes in brain functional connectivity following an integrated multimodal cognitive and whole-body coordination training program. Their findings demonstrated changes in functional connectivity associated with participation in coordinative training involving unfamiliar motor and cognitive challenges. Although the intervention examined was Life Kinetik rather than neurobic exercise specifically, the findings provide relevant evidence concerning the potential neural adaptations associated with combined cognitive-motor activities. Additionally, Liu et al. (2023) reported improvements in executive function and cerebral blood flow indicators following a structured exercise intervention among healthy young adults. These studies demonstrate that exercise-related cognitive adaptations may involve multiple neurological and physiological mechanisms, although the mechanisms underlying neurobic exercise require further investigation.

Empirical investigations have also examined neurobic exercise as an intervention intended to support cognitive performance. Napatpittayatorn et al. (2019) investigated neurobic exercise among older individuals with normal cognition and mild cognitive impairment, considering cognitive function and brain-derived neurotrophic factor as relevant outcomes. More recently, Sanghuachang et al. (2023) conducted a randomized controlled crossover trial evaluating a neurobic exercise program among community-dwelling older adults with mild cognitive impairment. Their research examined memory performance following participation in structured neurobic activities. These studies contribute to the growing literature concerning neurobic exercise and cognitive health. However, their findings should be interpreted within the characteristics of the populations studied. Evidence obtained from older adults, particularly individuals experiencing cognitive impairment, cannot automatically be generalized to healthy university students. Therefore, further investigation is needed to understand the relevance of neurobic exercise concepts in younger populations and educational settings.

The relationship between exercise and cognition is particularly relevant to sports science because sporting activities frequently require simultaneous physical and cognitive responses. Open-skill sports,

including activities performed in changing and unpredictable environments, demand continuous attention, perceptual processing, and rapid behavioral adjustments. Gu et al. (2019) systematically reviewed differences between open-skill and closed-skill exercise and found evidence suggesting that open-skill activities may provide greater benefits for certain cognitive functions. However, the authors emphasized that additional randomized controlled trials are required to establish stronger causal conclusions. These findings support the importance of cognitive engagement within movement-based activities while highlighting the need for careful interpretation of existing evidence. For sports science students, understanding the interaction between movement complexity and cognitive demands may provide a theoretical foundation for evaluating different exercise methods and developing evidence-informed training programs.

University students majoring in sports science are expected to develop interdisciplinary knowledge concerning exercise physiology, motor learning, sports psychology, and physical training. These fields involve understanding how physiological processes, environmental demands, and psychological mechanisms influence human movement and performance. Knowledge of cognitive function is particularly important because attention, memory, and executive control influence learning, movement coordination, and behavioral regulation. Students who understand the relationship between cognitive processes and physical exercise may be better prepared to interpret scientific evidence and evaluate the appropriateness of training interventions. Nevertheless, familiarity with an exercise concept does not necessarily indicate a comprehensive understanding of its neurological mechanisms or scientific evidence. Therefore, assessing students' knowledge should consider not only their awareness of neurobic exercise but also their understanding of cognitive function and the relationship between neurobic activities and cognitive outcomes.

Previous investigations have predominantly emphasized the effectiveness of neurobic exercise or related cognitive-motor interventions in improving cognitive performance. Studies conducted by Demirakca et al. (2016), Napatpittayatorn et al. (2019), and Sanghuachang et al. (2023) provide evidence concerning intervention-related outcomes and possible neurological adaptations. Meanwhile, broader systematic reviews have investigated the effects of exercise modalities on executive function, memory, and cognitive processing (Gu et al., 2019; Garrett et al., 2024; Singh et al., 2025). Although these investigations contribute valuable evidence regarding cognitive benefits, they do not directly establish the level of knowledge possessed by sports science students concerning neurobic exercise. This distinction represents an important research consideration because the effectiveness of an intervention and individuals' understanding of that intervention constitute different scientific questions. Examining knowledge can therefore complement intervention research by identifying educational strengths and potential gaps in understanding.

Within the Indonesian higher education context, particularly at Universitas Negeri Semarang, examining students' knowledge of neurobic exercise is relevant to the development of sports science education. Students enrolled in the Sports Science program receive instruction related to sports psychology, movement learning, and laboratory-based sports health practices. These academic experiences provide opportunities to develop knowledge concerning human movement and cognitive processes. However, completing relevant coursework does not necessarily demonstrate specific knowledge of neurobic exercise and its potential cognitive benefits. The present study addresses this educational question by examining knowledge across three dimensions: fundamental understanding of neurobic exercise, knowledge of cognitive functions, and understanding of the relationship between neurobic exercise and cognitive improvement. This approach distinguishes the present investigation from studies that directly evaluate changes in cognitive performance following exercise interventions.

The novelty of this study lies in its focus on assessing neurobic exercise knowledge among Indonesian sports science students rather than evaluating neurobic exercise as an intervention. By examining multiple knowledge indicators, the study seeks to identify areas in which students demonstrate stronger or weaker conceptual understanding. Such information may contribute to the evaluation of educational content related to cognitive-motor exercise and highlight topics requiring further academic attention. Therefore, this study aimed to determine the level of knowledge concerning neurobic exercise and its potential cognitive benefits among Sports Science students at Universitas Negeri Semarang, Indonesia. Specifically, the investigation assessed knowledge of neurobic exercise concepts, cognitive functions, and the relationship between neurobic exercise and cognitive improvement. The findings are expected to provide preliminary evidence supporting the development

of educational approaches that integrate cognitive science and exercise science within sports science curricula.

METHODS

Study Design

This study employed a quantitative descriptive research design using a survey method to assess knowledge of neurobic exercise and its potential cognitive benefits among Sports Science students at Universitas Negeri Semarang, Indonesia. The descriptive approach was selected to characterize participants' knowledge based on questionnaire responses. The study did not involve an exercise intervention or directly measure changes in participants' cognitive performance.

Research Setting and Participants

The study was conducted at the Faculty of Sports Science, Universitas Negeri Semarang, Indonesia, from January 31 to March 31, 2024. Participants were selected using purposive sampling based on predetermined eligibility criteria. The inclusion criteria required participants to be enrolled in the Sports Science program, to have completed and passed Sports Psychology, Measurement and Motor Learning, and Sports Health Laboratory Practice courses, and to be willing to participate in the study. A total of 56 students met the eligibility criteria and participated in the survey, comprising 26 male and 30 female students.

Research Instrument

Data were collected using a structured questionnaire consisting of 30 items organized into three knowledge indicators. The first indicator assessed fundamental knowledge of neurobic exercise, including its definition and types of activities. The second indicator evaluated students' understanding of cognitive functions. The third indicator assessed knowledge concerning the relationship between neurobic exercise and cognitive improvement. The questionnaire consisted of 12 items assessing neurobic exercise knowledge, nine items evaluating cognitive functions, and nine items examining the relationship between neurobic exercise and cognitive improvement. Each item contributed to the overall knowledge score, with a maximum possible total score of 30.

Data Collection Procedures

Data collection was conducted through offline and online questionnaire administration. The online questionnaire was distributed using Google Forms, while offline administration was conducted within the university environment. Participants were selected according to the established inclusion criteria and completed the questionnaire during the research period. Questionnaire responses were subsequently compiled for descriptive statistical analysis.

Data Analysis

Data were analyzed using descriptive statistics with Microsoft Excel 2019. The analysis included frequencies, percentages, mean scores, standard deviations, minimum scores, and maximum scores. The total knowledge score ranged from 0 to 30 and was classified into three categories: good knowledge (21–30), moderate knowledge (11–20), and low knowledge (0–10). Knowledge scores were also categorized separately for each indicator. For neurobic exercise knowledge, scores of 9–12 represented good knowledge, 5–8 moderate knowledge, and 0–4 low knowledge. For cognitive function knowledge and knowledge of the relationship between neurobic exercise and cognitive improvement, scores of 7–9 indicated good knowledge, 4–6 moderate knowledge, and 0–3 low knowledge. Descriptive findings were presented using frequency distributions, percentages, and summary statistics to describe the participants' knowledge levels.

RESULTS AND DISCUSSION

Characteristics of the Participants

This study involved 56 undergraduate students from the Sports Science program at Universitas Negeri Semarang, Indonesia. Participants were recruited through purposive sampling based on

predetermined academic requirements, including successful completion of Sports Psychology, Measurement and Motor Learning, and Sports Health Laboratory Practice courses. These criteria were established to identify students who had received relevant academic instruction concerning physical activity, human movement, and psychological aspects of sports performance.

The participants consisted of 26 male students (46.43%) and 30 female students (53.57%). The distribution indicates that both male and female students were represented in the study, with a slightly higher proportion of female participants. However, because participants were recruited through nonprobability sampling, their distribution should not be interpreted as representative of the entire Sports Science student population.

Table 1. Demographic Characteristics of the Participants

Characteristics	Category	Frequency (n)	Percentage (%)
Gender	Male	26	46.43
	Female	30	53.57
Total		56	100.00

Source: Primary research data (2024).

The characteristics of the participants provide important context for interpreting their knowledge of neurobic exercise and cognitive function. Students who have completed relevant sports science courses may have encountered concepts associated with coordination, motor learning, attention, perception, and psychological preparation. These academic experiences are theoretically relevant to understanding how cognitive and motor processes interact during physical activity.

Nevertheless, the present study did not specifically investigate whether previous coursework influenced participants' knowledge scores. Therefore, any relationship between academic experience and knowledge development should be regarded as a possible educational explanation rather than an established finding.

The inclusion of participants from a single academic program also provides a relatively specific educational context. Although such sampling is appropriate for describing the selected group, it restricts the generalizability of the findings to students from other universities, academic disciplines, and educational backgrounds. Accordingly, the results should be interpreted as reflecting the knowledge characteristics of the participating students rather than those of all Indonesian sports science students.

Knowledge of Neurobic Exercise

The first knowledge indicator examined participants' understanding of neurobic exercise, particularly its definition, fundamental principles, and examples of activities involving cognitive and sensory stimulation. This indicator comprised 12 questionnaire items, with a maximum possible score of 12. The results demonstrated that most participants achieved scores within the good knowledge category. Specifically, 48 students (85.71%) demonstrated good knowledge, while eight students (14.29%) demonstrated moderate knowledge. No participants were classified as having low knowledge.

Table 2. Distribution of Participants' Knowledge of Neurobic Exercise

Knowledge Category	Score Interval	Frequency (n)	Percentage (%)
Good	9–12	48	85.71
Moderate	5–8	8	14.29
Low	0–4	0	0.00
Total		56	100.00

Source: Primary research data (2024).

These findings indicate that the majority of participants demonstrated good fundamental knowledge of neurobic exercise according to the questionnaire classification criteria. The relatively high proportion of students in this category suggests that the participants were generally familiar with the concepts and activities assessed by the instrument.

Neurobic exercise is commonly described as an approach involving sensory stimulation, unfamiliar experiences, and modifications of habitual activities intended to encourage cognitive engagement. Katz and Rubin (2014) introduced neurobic activities as exercises that challenge established patterns of behavior by incorporating sensory experiences and novel cognitive demands. Examples include performing familiar activities using different sensory inputs, changing movement patterns, and engaging attention through unfamiliar tasks.

The conceptual characteristics of neurobic exercise have similarities with multimodal cognitive-motor training. Demirakca et al. (2016) investigated an integrated training program combining cognitive demands with whole-body coordination exercises. Their findings demonstrated changes in functional connectivity associated with participation in activities involving unfamiliar coordination tasks and cognitive challenges. The study provides a neurological perspective supporting further investigation of training approaches that simultaneously engage movement and cognitive processing. However, the intervention examined by Demirakca et al. was Life Kinetik training rather than the specific neurobic exercise activities described by Katz and Rubin. Therefore, its findings should be interpreted as supporting related cognitive-motor training principles rather than establishing the effectiveness of all neurobic exercise methods.

The present findings may reflect participants' familiarity with movement-based learning and coordination activities encountered during sports science education. Understanding motor coordination, sensory perception, and movement variation constitutes part of the conceptual foundation of several sports science subjects. Students exposed to these topics may recognize the general characteristics of neurobic exercise even when the terminology is not consistently incorporated into formal coursework.

However, a high knowledge category does not necessarily indicate comprehensive scientific understanding. The present questionnaire assessed responses to predetermined knowledge items rather than participants' ability to critically evaluate research evidence, explain neurological mechanisms, or design neurobic exercise interventions. Consequently, the results should be interpreted as evidence of knowledge performance within the assessed content domains.

This distinction is important because the term *neurobic exercise* is not necessarily interchangeable with other approaches such as dual-task exercise, coordinative training, exergaming, or integrated cognitive-motor training. Although these approaches may share certain characteristics, their protocols, training objectives, and supporting evidence differ.

Thus, the high proportion of participants demonstrating good fundamental knowledge represents a positive finding within the study population. Nevertheless, further investigation using more comprehensive knowledge assessments would be valuable for determining whether students can distinguish neurobic exercise from related cognitive-motor interventions and critically interpret the scientific evidence supporting different training approaches.

Knowledge of Cognitive Functions

The second indicator assessed participants' understanding of cognitive functions. This component comprised nine questionnaire items designed to evaluate fundamental knowledge regarding cognitive processes relevant to human behavior and physical activity. The findings demonstrated a different distribution from the neurobic exercise knowledge indicator. Only eight participants (14.29%) demonstrated good knowledge of cognitive functions, whereas 48 participants (85.71%) were classified within the moderate knowledge category. No participants obtained scores corresponding to low knowledge.

Table 3. Distribution of Participants' Knowledge of Cognitive Functions

Knowledge Category	Score Interval	Frequency (n)	Percentage (%)
Good	7–9	8	14.29
Moderate	4–6	48	85.71
Low	0–3	0	0.00
Total		56	100.00

Source: Primary research data (2024).

These results indicate that understanding of cognitive functions was less developed than fundamental knowledge of neurobic exercise among the participating students. Although most participants demonstrated good knowledge of neurobic exercise concepts, the majority achieved only moderate scores on questions specifically addressing cognitive functions. This difference represents one of the most important findings of the present study. Cognitive function encompasses several interrelated processes, including attention, memory, perception, inhibitory control, cognitive flexibility, and working memory. These abilities support the processing, organization, storage, and application of information during everyday activities and complex motor tasks.

Executive functions are particularly relevant in sports because they contribute to behavioral regulation, action selection, and adaptation to changing environmental demands. Ludyga et al. (2023) examined the effects of physical exercise and cognitive training on executive functions among young and middle-aged adults. Their network meta-analysis indicated that coordinative exercise and combined physical-cognitive training can improve selected aspects of executive function, particularly working memory and inhibitory control. These findings reinforce the importance of understanding cognitive mechanisms when evaluating exercise approaches that incorporate coordination and mental challenges. Similarly, Garrett et al. (2024) conducted a systematic review and Bayesian meta-analysis investigating the effects of acute physical activity on cognition among healthy young adults. Their analysis included 113 studies involving 4,390 participants and provided evidence that acute exercise can influence cognitive performance, although the magnitude of the effects varies across tasks and experimental conditions. Such findings demonstrate that cognitive function is a multidimensional construct influenced by several factors rather than a single ability that responds uniformly to exercise.

From an educational perspective, the predominance of moderate knowledge scores suggests that cognitive science concepts deserve additional attention within the sports science learning environment. Students may recognize general exercise terminology while having a less complete understanding of the cognitive processes associated with exercise interventions. For example, recognizing that an activity requires concentration differs from understanding the cognitive mechanisms involved in selective attention, sustained attention, or inhibitory control. Similarly, awareness that exercise may benefit memory does not necessarily imply an understanding of working memory, memory encoding, or long-term memory consolidation.

The distinction becomes particularly important when evaluating scientific research concerning exercise and cognition. Different studies may employ different cognitive assessment instruments, investigate different populations, and assess different domains of cognitive performance. Without sufficient conceptual knowledge, students may incorrectly interpret improvements in one cognitive domain as evidence of generalized enhancement across all cognitive functions. Nevertheless, the questionnaire did not provide item-level results in the available research report. Therefore, it is not possible to identify which specific cognitive concepts were most frequently misunderstood. The findings establish that most participants were classified as having moderate cognitive-function knowledge, but they do not determine whether particular weaknesses involved attention, memory, executive function, or other cognitive domains.

Further educational assessment should therefore examine students' understanding of individual cognitive constructs rather than relying exclusively on an aggregate knowledge category. Such assessment may help educators identify specific conceptual areas requiring additional instruction and develop more targeted teaching materials. The present findings also suggest that overall knowledge classifications should not obscure differences between knowledge domains. A student may demonstrate good understanding of the general definition and examples of neurobic exercise while possessing only moderate knowledge of the cognitive processes potentially associated with those activities. Consequently, educational efforts should emphasize both familiarity with exercise methods and understanding of the scientific mechanisms used to evaluate their potential benefits.

Knowledge of the Relationship Between Neurobic Exercise and Cognitive Improvement

The third indicator assessed participants' knowledge of the relationship between neurobic exercise and cognitive improvement. This component contained nine questionnaire items addressing participants' understanding of the objectives and potential cognitive benefits associated with neurobic exercise. The results revealed that 43 participants (76.79%) demonstrated good knowledge, 12 participants (21.42%) demonstrated moderate knowledge, and one participant (1.79%) demonstrated low knowledge.

Table 4. Distribution of Knowledge Regarding Neurobic Exercise and Cognitive Improvement

Knowledge Category	Score Interval	Frequency (n)	Percentage (%)
Good	7–9	43	76.79
Moderate	4–6	12	21.42
Low	0–3	1	1.79
Total		56	100.00

Source: Primary research data (2024).

The findings demonstrate that most participants achieved good knowledge scores regarding the relationship between neurobic exercise and cognitive improvement. This result is consistent with the relatively high proportion of students demonstrating good fundamental knowledge of neurobic exercise. Nevertheless, the proportion of participants classified within the good knowledge category was lower for this third indicator than for fundamental neurobic exercise knowledge. This difference suggests that identifying the characteristics of neurobic exercise may be easier for participants than understanding the relationship between these activities and cognitive outcomes.

Neurobic exercise is intended to introduce novelty and sensory engagement into everyday activities. The proposed cognitive benefits are generally associated with increased cognitive demands, behavioral adaptation, and engagement with unfamiliar tasks. However, the scientific evidence supporting specific neurobic interventions remains less extensive than the broader literature concerning exercise and cognition.

Sanghuachang et al. (2023) conducted a randomized controlled crossover trial examining the effectiveness of a neurobic exercise program among community-dwelling older adults with mild cognitive impairment. The study involved 32 participants and evaluated subjective and objective memory performance. The authors reported improvements in memory outcomes following neurobic exercise compared with a traditional brain exercise program. These findings provide direct experimental evidence supporting the potential usefulness of structured neurobic activities for selected cognitive outcomes in older adults with mild cognitive impairment. Nevertheless, the findings should not be generalized automatically to healthy university students because cognitive status, age, and intervention objectives differ between the populations.

A related investigation by Napatpittayatorn et al. (2019) examined neurobic exercise among older individuals with normal cognition and mild cognitive impairment. The study considered cognitive function and serum brain-derived neurotrophic factor (BDNF), a protein associated with neural adaptation and plasticity. This research provides additional context for understanding why neurobic exercise has attracted interest as a possible approach to cognitive stimulation. However, the relationship between neurobic exercise and cognitive improvement should not be presented as universally established. Intervention outcomes depend on the characteristics of participants, the specific activities performed, intervention duration, exercise frequency, and cognitive domains assessed. Furthermore, improvements observed in one cognitive test cannot necessarily be interpreted as improvements across all aspects of cognitive function.

Broader exercise research provides complementary evidence. Singh et al. (2025) conducted an umbrella review and meta-meta-analysis examining the effectiveness of exercise for improving general cognition, memory, and executive function. The review included 133 systematic reviews representing 2,724 randomized controlled trials and 258,279 participants. The researchers identified beneficial effects of exercise across the three cognitive outcome categories, although effects varied according to participant characteristics and intervention types. This extensive evidence supports the general relationship between physical exercise and cognition but does not establish that every neurobic activity produces comparable effects.

The distinction is particularly important when interpreting the present study because participants were asked about their knowledge of cognitive benefits rather than receiving neurobic exercise as an intervention. Therefore, the proportion of participants demonstrating good knowledge does not indicate that these students experienced improvements in memory, attention, or executive function. The present findings also suggest that knowledge concerning the relationship between exercise and cognition may not develop uniformly across different conceptual domains. Although 43 participants demonstrated

good knowledge of this relationship, only eight achieved good knowledge scores in the cognitive-function indicator. This discrepancy warrants attention because a scientifically informed understanding of exercise benefits requires familiarity with the cognitive processes used to evaluate those benefits.

Students may recognize general associations between neurobic exercise and cognitive improvement without demonstrating equally strong knowledge of the theoretical foundations underlying those associations. However, because the present study did not provide individual item-response patterns or cross-indicator analyses, this explanation remains a hypothesis requiring further investigation. Therefore, the findings highlight the importance of distinguishing recognition of potential exercise benefits from comprehensive knowledge of cognitive mechanisms and research evidence.

Knowledge of Neurobic Exercise and Cognitive Benefits

The knowledge was determined by combining scores from the three questionnaire indicators. The maximum possible score was 30, reflecting 12 items related to neurobic exercise, nine items assessing cognitive functions, and nine items examining the relationship between neurobic exercise and cognitive improvement. Descriptive statistical analysis demonstrated a mean knowledge score of 22.9, with a standard deviation of 2.47. The highest observed score was 28, whereas the lowest was 17.

Table 5. Descriptive Statistics of Overall Knowledge Scores

Statistical Indicator	Value
Number of participants	56
Number of questionnaire items	30
Maximum possible score	30
Mean score	22.9
Standard deviation	2.47
Highest observed score	28
Lowest observed score	17

Source: Primary research data (2024).

The mean score of 22.9 corresponds to approximately 76.33% of the maximum possible questionnaire score. This value provides a descriptive indication of the participants' overall performance on the knowledge assessment. The standard deviation of 2.47 indicates the reported dispersion of total scores around the sample mean. However, the descriptive statistics should be interpreted in relation to the questionnaire's scoring criteria. A mean score within the good knowledge interval does not imply that every participant possessed good knowledge, nor does it establish the accuracy of the questionnaire as a comprehensive measure of scientific understanding. The overall distribution demonstrated that 45 participants (80.36%) were classified as having good knowledge, while 11 participants (19.64%) were categorized as having moderate knowledge. No participants were classified as having low knowledge.

Table 6. Knowledge Classification of Sports Science Students

Knowledge Category	Score Interval	Frequency (n)	Percentage (%)
Good	21–30	45	80.36
Moderate	11–20	11	19.64
Low	0–10	0	0.00
Total		56	100.00

Source: Primary research data (2024).

The findings indicate that most participating Sports Science students demonstrated good overall knowledge of neurobic exercise and its potential cognitive benefits according to the established classification criteria. Nevertheless, the results reveal important differences between individual knowledge indicators. Fundamental knowledge of neurobic exercise showed the highest proportion of participants in the good category (85.71%), followed by knowledge concerning the relationship between

neurobic exercise and cognitive improvement (76.79%). In contrast, only 14.29% of participants achieved good knowledge scores for cognitive functions.

This pattern is particularly relevant because it demonstrates that the overall knowledge category does not adequately represent all dimensions of participants' understanding. Although 80.36% of students achieved good total scores, most participants demonstrated only moderate knowledge of cognitive functions. The pattern suggests that students may have acquired greater familiarity with neurobic exercise terminology and its commonly described benefits than with the underlying cognitive concepts. Nevertheless, this interpretation cannot establish the causes of the differences between knowledge indicators. Rithaudin and Sari (2019) highlighted the importance of incorporating cognitive competencies into physical education learning activities, indicating that cognitive development should be addressed alongside psychomotor learning objectives. Similarly, Salasiah et al. (2020) examined cognitive assessment instruments in physical education and identified challenges in the implementation of cognitive assessment within educational practice. These studies provide relevant educational context for the present findings, although neither directly investigated neurobic exercise knowledge among university students.

An important consideration concerns the number of questionnaire items assigned to each indicator. The fundamental neurobic exercise component contributed 12 items to the total score, whereas the other two components contributed nine items each. Consequently, the overall classification combines indicators with different maximum scores. Moreover, the knowledge categories were based on predetermined score intervals, and the available research report does not explain the empirical basis for selecting these thresholds. Therefore, the classification of good, moderate, and low knowledge should be understood as operational categories employed in this study rather than universally validated standards. The importance of systematic cognitive assessment is also reflected in Salasiah et al. (2020), who investigated the implementation of cognitive assessment instruments in physical education. Although their study focused on school-level educational assessment, it reinforces the importance of clearly defined assessment procedures when interpreting cognitive knowledge outcomes.

These considerations reinforce the importance of reporting both total knowledge scores and indicator-specific results. Presenting only the overall distribution could conceal areas requiring further educational attention. From a practical perspective, the findings provide preliminary information about the conceptual knowledge demonstrated by the selected Sports Science students. However, stronger conclusions regarding educational effectiveness would require additional evidence, including validated measurement instruments, comparisons across academic levels, and investigations involving students from different institutions.

Scientific Interpretation and Implications for Sports Science Education

The present findings provide insight into the knowledge of neurobic exercise among Sports Science students, particularly in relation to cognitive functions and potential exercise-related cognitive benefits. The results suggest that participants generally demonstrated good knowledge of neurobic exercise concepts, although their understanding of cognitive functions was comparatively less developed. These findings have implications for sports science education because the relationship between cognitive processing and movement performance is increasingly recognized in exercise research. Sports frequently require athletes to perceive environmental information, maintain attention, select appropriate responses, and coordinate movements under changing conditions.

Gu et al. (2019) systematically reviewed the effects of open-skill and closed-skill exercise on cognitive function. Their findings suggested that open-skill activities may provide greater benefits for certain cognitive outcomes, although the available evidence included a substantial proportion of observational studies. The authors emphasized the need for additional rigorous experimental research to confirm differences between exercise modalities. These findings are relevant to sports science education because they demonstrate how cognitive demands may differ between physical activities.

Within the Indonesian sports context, Saputra et al. (2017) investigated the effects of brain jogging on movement coordination among pencak silat athletes. Their experimental investigation examined a training approach combining movement and cognitive stimulation to support coordinative performance. Although brain jogging differs conceptually from neurobic exercise, both approaches involve cognitive engagement alongside movement-related activities. This provides a relevant example of how cognitive-motor training concepts have been investigated within Indonesian sports research.

Similarly, Komarudin et al. (2021) investigated the effects of Life Kinetik training on self-confidence among athletes participating in team and individual sports. Their findings indicated that Life Kinetik training could contribute to improvements in athletes' self-confidence. Although self-confidence represents a psychological outcome rather than a direct measurement of cognitive performance, the study demonstrates the broader application of integrated movement-based training approaches in sports settings. Together, these investigations illustrate the importance of distinguishing different training methods and their intended outcomes when developing sports science knowledge.

Research involving young adults also provides relevant context. Liu et al. (2023) investigated the relationship between physical exercise, cerebral blood flow, and executive function through a randomized controlled trial. Their findings contribute to understanding the physiological processes potentially associated with exercise-related cognitive changes. However, such mechanisms were not directly examined in the present survey.

Similarly, Ludyga et al. (2023) found that exercise involving coordination demands and combined physical-cognitive training may benefit selected executive functions. This evidence suggests that understanding cognitive demands is relevant to the design and evaluation of contemporary exercise interventions.

Previous research has also examined exercise approaches intended to support cognitive performance among older populations. Amtonis and Fata (2014) investigated the effects of brain gym exercises on cognitive function among older adults and reported improvements following the intervention. Their findings provide contextual evidence concerning movement-based cognitive stimulation. Nevertheless, brain gym and neurobic exercise should not be treated as identical interventions, and results obtained from older adults cannot be directly generalized to university students.

Dighe et al. (2020) investigated a combined program of weight-bearing and neurobic exercises among elderly individuals, focusing on bone health and physical function. Their research demonstrates that neurobic exercises have been incorporated into physical activity programs examining outcomes beyond cognition. However, because their investigation involved combined interventions and primarily physical outcomes, it should not be interpreted as direct evidence that neurobic exercise independently improves cognitive performance among young adults.

The conceptual development of neurobic exercise has also received attention in educational settings. Zemskova and Ponomareva (2020) discussed the introduction of neurobics into the teaching process for students in a university physiology department. Their work provides an educational perspective on incorporating neurobic activities into learning environments. However, its relevance to the present study is primarily conceptual, as it does not establish the effectiveness of neurobic instruction in improving knowledge among Indonesian sports science students.

In addition to scientific investigations, practical neurobic exercise activities have been described in educational and popular publications. Scotts (2014), for example, presented collections of mental exercises and puzzles intended to encourage cognitive engagement. Such materials may illustrate the range of activities commonly associated with neurobic exercise, but they should not be treated as equivalent to controlled experimental evidence. This distinction is important because students need to differentiate between practical exercise recommendations and scientific findings regarding cognitive outcomes.

In the context of the present study, these scientific and educational developments emphasize the importance of integrating cognitive concepts into sports science instruction. Students should be encouraged not only to identify exercise methods but also to understand the cognitive outcomes those methods are intended to influence and the quality of evidence supporting their application.

The relatively moderate performance on the cognitive-function indicator suggests a potential area for educational improvement. Additional instruction concerning attention, memory, executive function, and motor-cognitive interaction may support a more comprehensive understanding of exercise science. The educational relevance of cognitive assessment has also been emphasized by Rithaudin and Sari (2019) and Salasiah et al. (2020), whose investigations highlight the importance of incorporating cognitive learning objectives and assessment procedures into physical education.

Furthermore, exposure to different exercise approaches, including neurobic exercise, brain jogging, and Life Kinetik training, may provide opportunities for students to develop a more critical understanding of cognitive-motor interactions. However, these approaches should be introduced with appropriate explanations of their differences, research evidence, and intended outcomes. Such

instruction could help students distinguish between established scientific findings and theoretical or practical claims concerning cognitive enhancement.

Nevertheless, the study did not evaluate teaching methods, curriculum content, or changes in knowledge following instruction. Consequently, recommendations for educational improvement should be interpreted as implications arising from the descriptive findings rather than demonstrated effects of a particular educational intervention.

Research Limitations and Future Directions

Several limitations should be considered when interpreting the findings. First, the study employed a descriptive survey design involving 56 participants selected through purposive sampling at a single university. Consequently, the findings cannot be generalized confidently to all Sports Science students in Indonesia.

Second, the research measured knowledge rather than cognitive performance or responses to neurobic exercise interventions. Therefore, the findings do not establish whether participants experienced cognitive improvements or whether their knowledge influenced their exercise behavior. This distinction is particularly important when comparing the present findings with intervention studies. For example, Amtonis and Fata (2014) investigated cognitive changes following brain gym exercises, whereas Saputra et al. (2017) examined movement coordination after brain jogging training. In contrast, the present investigation focused exclusively on participants' knowledge, without implementing any exercise intervention.

Third, the available research report did not provide sufficient information about questionnaire development, content validation, construct validity, or reliability testing. Terwee et al. (2018) emphasized that content validity requires systematic evaluation of an instrument's relevance, comprehensiveness, and comprehensibility. Although their COSMIN framework was developed primarily for patient-reported outcome measures, these principles provide useful methodological considerations when developing knowledge questionnaires.

The importance of assessment instrument development is also reflected in Salasiah et al. (2020), who examined cognitive assessment practices in physical education. Their findings provide additional educational context regarding the importance of systematic assessment procedures. Future studies should therefore establish the validity and reliability of knowledge assessment instruments before drawing broader conclusions regarding students' understanding.

Fourth, the present report did not explain the methodological justification for establishing the knowledge classification thresholds. Future studies should describe how score intervals are determined and evaluate whether the proposed categories adequately distinguish different levels of understanding.

Fifth, the study reported descriptive statistics without conducting analyses of potential relationships between knowledge scores and participant characteristics. Further studies could examine whether academic year, previous learning experiences, or other relevant educational variables are associated with neurobic exercise knowledge.

Future investigations should also consider developing a validated questionnaire that differentiates knowledge of neurobic exercise definitions, cognitive processes, mechanisms of action, and empirical evidence. Such an instrument could provide a more detailed understanding of students' educational needs.

Multicenter studies involving students from different universities would strengthen the external validity of future findings. Longitudinal or educational intervention designs could also evaluate changes in knowledge following structured instruction concerning exercise neuroscience and cognitive-motor training.

Future studies may additionally investigate whether educational programs introducing neurobic exercise concepts contribute to improvements in students' scientific understanding. Such investigations could be informed by previous educational discussions concerning neurobic exercise (Zemskova & Ponomareva, 2020) and research emphasizing cognitive competencies in physical education (Rithaudin & Sari, 2019).

Finally, future research should distinguish between studies assessing knowledge and studies investigating the effectiveness of neurobic exercise. Both approaches contribute to scientific understanding, but they address different research objectives and require different methodological designs.

Contribution of the Study

The principal contribution of this study is the identification of differences between knowledge dimensions concerning neurobic exercise and cognitive benefits among Indonesian Sports Science students.

The findings demonstrate that good overall knowledge does not necessarily correspond to equally strong understanding across all cognitive-related concepts. Although most participants demonstrated good fundamental knowledge of neurobic exercise and its potential cognitive benefits, the majority showed only moderate knowledge of cognitive functions.

This distinction provides a useful basis for considering how exercise-related cognitive concepts are addressed within sports science education. Previous investigations concerning cognitive learning objectives and assessment practices in physical education (Rithaudin & Sari, 2019; Salasiah et al., 2020) provide relevant educational context for interpreting the importance of these differences.

Furthermore, previous research involving brain jogging and Life Kinetik training in Indonesian sports settings (Komarudin et al., 2021; Saputra et al., 2017) demonstrates the relevance of understanding movement-based cognitive and psychological training approaches within sports science. However, the present study extends this discussion toward students' conceptual knowledge rather than intervention-related outcomes.

By identifying differences in knowledge across three indicators, the study offers preliminary descriptive evidence that may inform the development of more focused educational assessments.

The results indicate that participating Sports Science students at Universitas Negeri Semarang demonstrated good knowledge of neurobic exercise and its potential cognitive benefits according to the study's questionnaire criteria. Nevertheless, the predominance of moderate knowledge regarding cognitive functions highlights the importance of strengthening conceptual understanding of cognition within sports science education.

CONCLUSION

This study concluded that Sports Science students at Universitas Negeri Semarang, Indonesia, demonstrated a generally good level of knowledge regarding neurobic exercise and its potential cognitive benefits. Among the 56 participants, 80.36% were classified as having good knowledge, while 19.64% demonstrated moderate knowledge, with a mean score of 22.9 ± 2.47 . The findings revealed differences across the three knowledge indicators, with 85.71% of participants demonstrating good fundamental knowledge of neurobic exercise and 76.79% showing good knowledge of its relationship with cognitive improvement. However, 85.71% of participants exhibited only moderate knowledge of cognitive functions, indicating a gap between familiarity with neurobic exercise and understanding of cognitive processes. These findings highlight the importance of strengthening cognitive science concepts within sports science education, particularly regarding attention, memory, executive functions, and cognitive-motor interactions. The study provides preliminary evidence for identifying areas requiring further educational attention. Future research should involve larger and more diverse samples, employ validated and reliable assessment instruments, and examine factors associated with students' knowledge to support the development of evidence-based sports science education.

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