ORIGINAL SCIENTIFIC PAPER

Methodological Discrepancies in Lower Limb Average Power Calculation in a Repeated Vertical Jump Test: A Preliminary Study

Vlad Adrian Geantă[1,3], Pierre Joseph de Hillerin[1,2]

Affiliations: [1]Doctoral School of Sport Science and Physical Education, National University of Science and Technology Politehnica Bucharest, Pitesti University Center, Pitesti, Romania, [2]Neuromotrica - Information for Sport and Human Performance Ltd. Bucharest, Romania, [3]Aurel Vlaicu University of Arad, Faculty of Physical Education and Sport, Arad, Romania

Correspondence: Vlad Adrian Geantă. Doctoral School of Sport Science and Physical Education, Pitești University Center, National University of Science and Technology Politehnica Bucharest, 110253 Pitești, Romania. Aurel Vlaicu University of Arad, Faculty of Physical Education and Sport, 2-4, Elena Dragoi, 310330 Arad, Romania. E-mail: vladu.geanta@gmail.com

Abstract

Repeated vertical jump assessments are commonly used to evaluate lower limb average power and neuromuscular performance. However, discrepancies persist regarding the accuracy and consistency of different computational models used to estimate average power. Purpose: This study aimed to evaluate and compare three distinct models; Bosco, Miron Georgescu (MG), and Modified Miron Georgescu-15s (MGM-15) used during a 15-second repeated vertical jump test. Methods: Five male athletes participated in the testing protocol, using the OptoJump system. Power output (W/kg) was calculated through each model, based on jump height, flight time, and ground contact time. Statistical differences between models were assessed using repeated-measures ANOVA with Bonferroni correction. Results: Results revealed significant discrepancies: Bosco produced the highest estimates (M = 39.43 ± 7.74 W/kg), followed by MG (M = 20.38 ± 5.60 W/kg), while MGM-15 yielded the lowest values (M = 4.14 ± 0.54 W/kg). ANOVA confirmed a strong effect of model type on output [$F(2,8) = 111.50$, $p < .001$, $\eta^2_p = .965$], with all pairwise comparisons significant. Conclusion: These findings highlight the critical impact of model selection on performance interpretation. While Bosco's model tends to overestimate power, the MGM-15 protocol may offer a more conservative and physiologically coherent alternative. Considering that repeated vertical jumps are typically performed in a "ball-like" elastic manner, the resulting power values may better reflect psycho-neuromotor quality such as anticipatory control and coordination rather than pure energetic output. The study underscores the need for standardized methodologies in jump-based power assessments. Future research with larger and more diverse cohorts is warranted to confirm these results and support the development of validated and reliable evaluation tools.

Keywords: *vertical jump, average power, lower limb, calculation models, athlete assessment*

@MJSSMontenegro
ASSESSMENT IN SPORT PERFORMANCE
http://mjssm.me/?sekcija=article&artid=305

Cite this article: Geantă, V.A., de Hillerin, P.J. (2025) Methodological Discrepancies in Lower Limb Average Power Calculation in a Repeated Vertical Jump Test: A Preliminary Study. *Montenegrin Journal of Sports Science and Medicine, 21 (2)*, Ahead of print. https://doi.org/10.26773/mjssm.250910

Received: 25 April 2025 | Accepted after revision: 26 July 2025 | Early access publication date: 15 August 2025 | Final publication date: 15 September 2025

Conflict of interest: None declared.

Introduction

Assessing athletes' motor performance is a fundamental aspect of sport science, offering essential insights into their functional capacities and neuromuscular responses (Nishiumi et al., 2023). Among the most widely used methods for this purpose are vertical jumps tests, valued for their non-invasive nature, time efficiency, and strong correlation with lower limb power and coordination (Eythorsdottir et al., 2024; França et al., 2023). These tests are applied both as single efforts or repeated across various sports disciplines, often serving as indicators of explosive strength, fatigue resistance, and athletic readiness (Grădinaru et al., 2024; García-Ramos et al., 2023).

However, inconsistencies in computational models used to calculate average power from repeated vertical jump test data pose significant challenges. These discrepancies arise largely from differences in how models interpret biomechanical parameters, such as jump height, flight time, and ground contact duration. Consequently, identical test performance may yield divergent results depending on the chosen model, raising concerns regarding the validity and comparability of findings.

To contextualize these issues, the historical development of repeated vertical jump assessment models is worth reviewing. One of the earliest structured approaches, to repeated jump assessment was developed by Romanian physician Miron Georgescu in 1953. His approach, known today as the "Georgescu Test" is still used in specific regions of Latin America and provides a foundation for examining lower limb performance (Georgescu, 1953; Cherebețiu, personal communication, 2004). Decades later, Bosco et al. (1983) proposed a new computational model for estimating mechanical average power, which has since become a global reference. Despite early critiques, the Bosco model remains widely used in sport performance research and monitoring (Kaufmann et al., 2021; Natera et al., 2023; de Carvalho et al., 2024).

These traditional models, however, have notable shortcomings. Hillerin (1997) argued that neither Georgescu's test nor Bosco's method truly assess anaerobic effort capacity, as they disregard the elastic mechanisms involved in movement execution. He further contended that their output results can contradict physiological realities by overattributing mechanical power to muscular effort, while neglecting neuromotor coordination and passive elastic recoil.

To address these limitations, Hillerin (1997) proposed a more comprehensive framework that integrates psycho-neuro-motor variables, intersegmental coordination, and upper limb involvement. The term psycho-neuro-motor refers to an integrative view of human movement that combines psychological intent, neural coordination, and muscular execution as interconnected elements (Marin et al., 2015). This framework highlights not only muscular force but also anticipatory control. Anticipatory control refers to the neuromuscular system's preparation for upcoming motor demands (Botezatu, 2013). It also includes timing and sensorimotor adaptations, which are crucial for effective performance (Botezatu et al., 2014).

Complementing this theoretical perspective, recent evaluations of commercial systems like OptoJump have raised concerns about the reliability of traditional mechanical formulas, which may significantly overestimate actual average power output when elastic and neuromotor components are not accounted for (Geantă & de Hillerin, 2023).

In response, the Modified Miron Georgescu method (MGM-15), was developed to address these limitations by incorporating not only mechanical parameters such as force, power, and elasticity but also psycho-neuro-motor indicators related to control, coordination, and fatigue. Initially, redefined at the Romanian Centre for Sports Research, the MGM-15 protocol evaluates lower limb power during repeated jumps under time constraints, like Bosco and MG methods, but across bilateral and unilateral efforts. Unlike traditional models, it emphasizes both energetic and control parameters, offering a more nuanced understanding of neuromuscular performance in a general task that remains functionally representative (Hillerin, 1997).

Given these divergent methodologies, it becomes essential to systematically evaluate the validity and reliability of the primary computational approaches used in repeated vertical jump testing. Accurate comparisons are essential for performance diagnostics, training design, and rehabilitation protocols. To date, no study has directly compared the Bosco, MG, and MGM-15 models for calculating average power in a repeated 15-second vertical jump protocol. Establishing such comparisons is crucial given the prevalence of these models and the implications of their methodological divergence.

This study therefore aims to address that gap by analyzing methodological discrepancies among these models and identifying the most reliable and physiologically grounded approach for estimating lower limb average power.

Materials and Methods

Research Design

This preliminary study employed a within-subject comparative design to evaluate discrepancies between three distinct models used to estimate average lower limb power during a 15-second repeated vertical jump test. Our research focused on identifying discrepancies between Bosco, MG, and MGM-15 average power calculation models using kinematic data.

Participants

Five male students from the Faculty of Physical Education and Sport, Aurel Vlaicu University of Arad, Romania, were randomly selected to participate in the study. All participants were physically active and had prior experience with vertical jump testing. The mean age was 20 ± 0.45 years, the average height was 178.6 ± 4.72 cm, and the average body weight was 73 ± 8.12 kg.

All participants provided written informed consent prior to inclusion in the study. The research protocol was reviewed, registered, and approved by the institutional ethics committee (Registration number:210/16.04.2025). The study was conducted in accordance with the clarify guidelines and the ethical standards of the Declaration of Helsinki.

Experimental Procedure

Each participant performed a single 15-second repeated vertical jump test with arm swing, aiming to maximize jump height while minimizing ground contact time. The test was conducted bilaterally using the OptoJump Next System (Microgate, Italy), a validated optical measurement system (Microgate, n.d.). Raw kinematic data as jump height (h), flight time (T_f), and ground contact time (T_c) were collected and used in three power calculation models:

Bosco model (Bosco et al., 1983)
MG model (Georgescu, 1953)
MGM-15 model (Hillerin, 1997)

DOI 10.26773/mjssm.250910

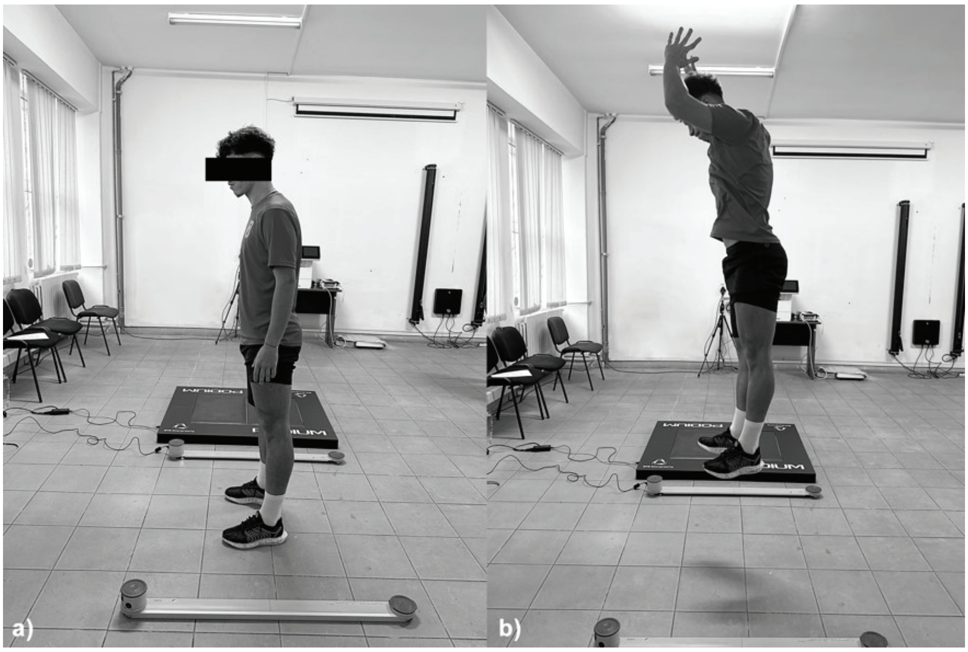

Figure 1. 15s Repetitive vertical jump test on both legs with arm swings.

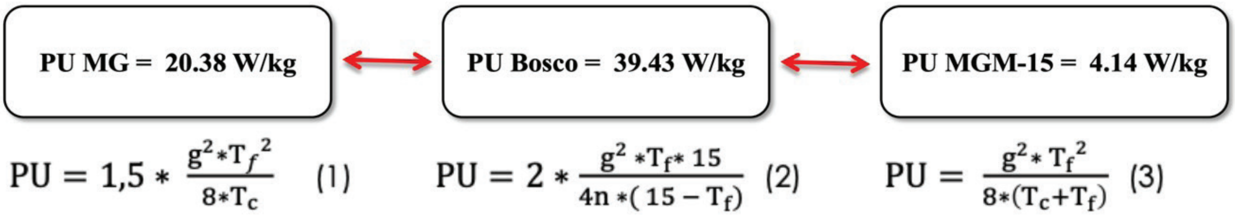

Figure 2. Different methodologies for estimating average power (PU) in the 15-seconds repeated jumps test, according to Miron Georgescu, Bosco, and MGM-15 models.
Where: PU = Average power, g = Gravitational acceleration (typically 9.81 m/s^2), Tf = Flight Time (included in the 3rd formula to account for the muscle contraction phase, analogous to a two-stroke engine: contraction–relaxation), Tc = Contact Time, 15= Test duration, PU MG = Average Power Miron Georgescu Model, PU Bosco = Average Power Bosco Model, PU MGM-15 = Average Power Modified Miron Georgescu 15-s Model

Average Power Calculation Formula

The average power (PU) output was calculated using the following equations:

Bosco method: $PU = 2 * \frac{g^2 * T_f * 15}{4n * (15 - T_f)}$ (1)

Miron Georgescu method: $PU = 1{,}5 * \frac{g^2 * T_f^2}{8 * T_c}$ (2)

MGM-15 method: $PU = \frac{g^2 * T_f^2}{8 * (T_c + T_f)}$ (3)

Where:
PU = Average power output (W/kg)
m = Body mass (kg)
g = Gravitational acceleration (typically 9.81 m/s^2),
n = Number of jumps
t= Total test time (15 seconds)
T_f = Flight time (s)
T_c = Contact time (s)

Statistical Analysis

As this was a preliminary study with a small and homogenous sample (N=5), statistical analyses were conducted with a focus on within-subjects consistency rather than generalizability. Data were analyzed using IBM SPSS Statistics version 23 (IBM Corp., Armonk, NY, USA). Descriptive statistics (mean and standard deviation) were computed for each of the three computation models. The assumption of normality for each variable was assessed using the Shapiro-Wilk test, which is appropriate for small samples. All variables met the criteria for normal distribution ($p > .05$). To evaluate differences in estimated average power output across three methods, a one way repeated-measures analysis of variance (ANOVA) was conducted. Mauchly's test of sphericity was used to assess the assumption of sphericity. When assumption was violated, the Greenhuose-Geisser correction was applied. Effect size was assessed using partial eta squared (η^2_p), with values interpreted as small (≥ .01), medium (≥ .06), or large (≥ .14), according to Cohen's (2013) guidelines. For post hoc analysis, Bonferroni-adjusted pairwise comparison was used to explore differences between each pair of methods while controlling the family-wise error. The threshold for statistical significance was set at $p < .05$.

Results

Descriptive statistics for the three computational models Bosco, MG and MGM-15 are presented in Table 1. The Bosco model yielded the highest average power output (M= 39.45

± 7.74 W/kg), followed by the MG model (M= 20.38 ± 5.60 W/kg), while the MGM-15 model produced the lowest values (M= 4.14 ± 0.54 W/kg).

As illustrated in Figure 3, mean power output values followed the same pattern across all participants, with Bosco showing the highest estimates and MGM-15 the lowest.

Table 1. Average Power Output by Method

Method	M (W/kg)	SD (W/kg)
Bosco	39.43	7.74
MG	20.38	5.60
MGM-15	4.14	0.54

Note. M = Mean; SD = Standard Deviation; MG = Miron Georgescu; MGM-15 = Modified Miron Georgescu Method for 15s. Data reflects average power output in W/kg for each method during the 15-second repeated vertical jump test.

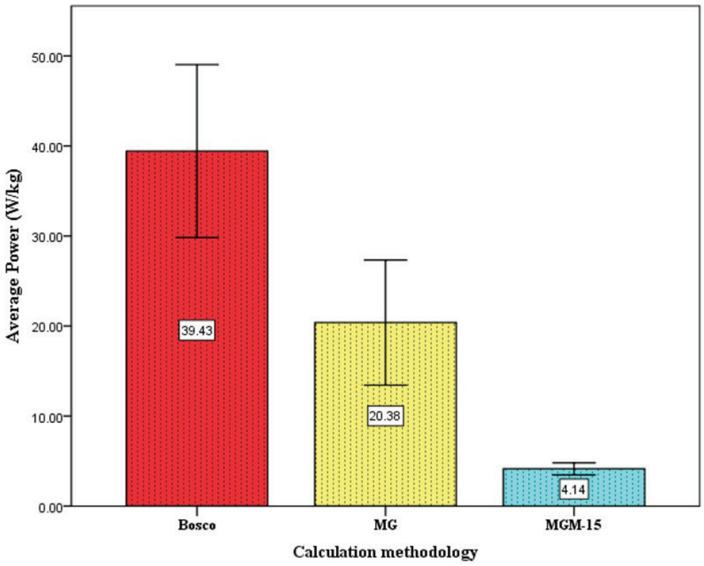

Figure 3. Average power values calculated using the three methodologies for 15s Jumps

A repeated-measures ANOVA was conducted to assess whether differences between the models were statistically significant. Results indicated a significant effects of calculation methods on power output, F (2,8) = 111.50, p < .001, with a large effect size (η2p = .965). The assumption of sphericity was violated (Mauchly's W = .073, p = .020), so Greenhouse-Geisser correction was applied. These results are summarized in Table 2.

Table 2. Repeated-Measures ANOVA for Average Power Output

Source	SS	df	MS	F	p	η^2_p
Method	3119.98	2	1559.99	111.5	< .001	0.965
Error	111.92	8	13.99			

Note. Greenhouse-Geisser correction was applied due to violation of sphericity (Mauchly's W = .073, p = .020).

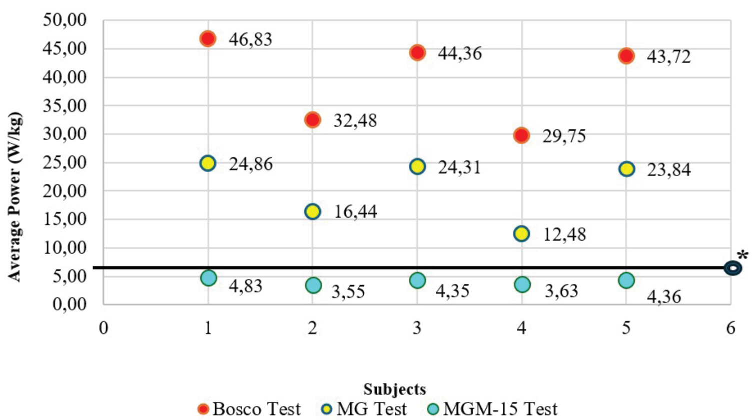

Figure 4. Average power output for each subject

DOI 10.26773/mjssm.250910

To illustrate consistency across participants, Figure 4 presents the average power output for each subject under all three models.

Post hoc analysis using Bonferroni-adjusted pairwise comparisons revealed that all pairwise differences were statistically significant. Bosco yielded significantly higher power outputs than MG and MGM-15, and MG values were significantly greater than MGM-15. These findings are detailed in Table 3.

Table 3. Bonferroni-Adjusted Pairwise Comparisons

Comparison	Mean Difference (W/kg)	95% CI	p
Bosco vs MG	19.04	[14.85, 23.24]	< .001
Bosco vs MGM-15	35.29	[22.50, 48.08]	< .001
MG vs MGM-15	16.25	[7.19, 25.31]	<. 006

Note. All pairwise differences were statistically significant ($p < .05$) using Bonferroni correction. MG = Miron Georgescu; MGM-15 = Modified Miron Georgescu Method for 15s.

These results underscore the significant methodological discrepancies in average power calculation depending on the computation model employed.

Discussion

The study aimed to evaluate the validity and methodological coherence of three computational models Bosco, MG, and MGM-15, used to calculate average power output during a 15-second repeated vertical jump test. Statistical analysis revealed consistent and substantial discrepancies between these methods. The Bosco model yielded the highest average power values, followed by MG, with MGM-15 generating the most conservative values. Repeated measures ANOVA confirmed that these differences were statistically significant, with large effect sizes. All pairwise comparisons remained significant after the Bonferroni correction.

These findings raise critical concerns regarding how mechanical power is conceptualized and quantified in repeated vertical jump testing protocols. The discrepancies observed are not mere numerical artifacts but rather reflect fundamental theoretical inconsistencies between the test execution and the computational assumptions of each model.

Misinterpretation Risk in Traditional Models

An important implication of these findings is the risk of misinterpretation when relying solely on mechanical models like Bosco or MG. Although these models may appear sensitive to performance changes, they consistently produce inflated power values, potentially distorting conclusions about actual neuromuscular capacity.

To illustrate this critique in practical terms, the following non-biological simulation demonstrates the theoretical inconsistency. Rather than testing an athlete, the model was applied to a passive system, a standard basketball whose behavior is governed purely by mechanical laws. Geantă & de Hillerin (2023) conducted this controlled experiment to test how the Bosco formula interprets repeated jump behavior. When dropped from 1 meter and allowed to bounce freely for 15 seconds, the actual energy input was approximately 6.12 Joules. However, applying the Bosco formula resulted in an estimated energy output exceeding 2,200 Joules, more than 350 times higher. In other words, the model mistakenly attributes elastic rebound, a passive mechanical phenomenon, to active muscular work (Monroy et al., 2007).

Importantly, this result is not caused by the measurement tool. Rather, it reflects the oversimplified computational assumptions embedded in the Bosco model. For instance, it treats flight time and contact duration as direct proxies for muscular power, even when the subject is an object. This underscores the model's conceptual limitations. The model fails to account for the biomechanical complexity of human tissue. This limitation calls for a deeper exploration of the biomechanical principles underlying elastic energy and the muscle-tendon complex.

Elastic Energy and the Muscle-Tendon Complex

Briefly, the muscle-tendon complex enables movement by storing and releasing elastic energy via its viscoelastic properties, functioning both as springs and dampers (Wu et al., 2022; Roberts & Konow, 2013). These tissues contribute to force production not only through active muscular contraction but also by passively returning stored energy (Bojsen-Møller & Magnusson, 2019)

Such an approach overlooks essential biomechanical realities. In particular, it ignores the neuromotor control and viscoelastic behavior of the muscle-tendon complex (Roberts & Konow, 2013). Viscoelasticity refers to the muscle-tendon tissues' elastic and viscous characteristics, affecting energy dissipation and recovery during dynamic motion (Wu et al., 2022). Elastic recoil describes the passive release of this stored energy during movement, contributing to force output without additional active contraction (Fukashiro et al., 2006; Roberts, 2016). In reality, a substantial part of the force comes from passive recoil within the muscle-tendon complex (Holt & Mayfield, 2023). These tissues act both as elastic springs and viscous elements. They store and release energy depending on the movement demands (Mierke, 2022).

This biomechanical complexity is critical in protocols promoting elastic rebound. For example, instructing athletes to "jump like a ball" leverages the muscle-tendon complex's ability to store and release energy (Georgescu, 1953; Bosco et al., 1983). These protocols reveal critical limitations in traditional models, as the discrepancy in average power in the Bosco and MG models challenges energy conservation principles (Shahsavari & Torkaman, 2022; Haseli, 2020). These interpretations neglect neuromuscular, viscoelastic, and control-related components of human movement (Geantă & de Hillerin, 2023).

For example, the main cause of misinterpretation stems from the oversimplified assumption that vertical movement during jumping is entirely the result of muscular contraction (Akl, 2013). As a result, simplified models fail to distinguish between active contractile effort and passive viscoelastic return. This leads to systematic overestimation of power outputs. Both Bosco and MG models derive energy from the potential energy at the apex of the jump ($m \times g \times h$), multiply it by a coefficient of 1.5 in the MG model, and by 2.0 in Bosco's, and divide the results exclusively by ground contact time. This computational logic treats muscle power as a continuous and uniform energy process. However, it disregards the phasic nature of human movement.

In reality, muscle action follows a biphasic cycle, consisting of contraction and relaxation phases (Sozbir et al., 2016). A useful analogy comes from internal combustion engines. Power is not measured solely during the explosion stroke but across the entire operational cycle (Norton, 2013). Similarly, muscular output should be assessed across the full motor sequence. This includes not only the ground contact phase but also preactivation, amortization, elastic recoil, and control during flight (Roberts, 2016; Satkunskiene et al., 2021; Goecking et al., 2024).

Advantages of the MGM-15 Model

Unlike traditional models, MGM-15 addresses biomechanical and neuromotor complexity by integrating asymmetry, fatigue patterns, and motor control variables (Hillerin, 1997). This shift enables more accurate and personalized athlete evaluations by capturing motor coordination and control under dynamic constraints, not just force or jump height.

While historically relevant, the Georgescu method (MG) reflects mid-20th century physiological assumptions and lacks sensitivity to inter-jump variability, coordination fluctuations, and fatigue-related motor adaptations. These limitations reduce its applicability to modern, high-resolution assessment of complex motor performance.

Moreover, the MGM-15 introduces a paradigm shift by framing vertical jump performance within a psycho-neuro-motor context (Geantă & de Hillerin, 2023). It incorporates both bilateral and unilateral effort under time constraints, enabling the detection of intra-individual asymmetries, fatigue responses, and coordination precision (Hillerin, 1997).

This aligns with contemporary theories of anticipatory motor control. In this view, performance depends not only on force production but also on timing, rhythm, anticipation, and adaptive mechanisms strategies (Botezatu, 2013, Botezatu et al., 2014).

Practical Applications and Diagnostic Utility

Building on these methodological strengths, the MGM-15 protocol has already been employed in applied sport settings to assess movement control, asymmetry, and fatigue dynamics. In volleyball, it has been used to monitor explosive power (Mureșan et al., 2016), in football to optimize agility-based training interventions (Ciobotaru et al., 2014), and in judo to evaluate neuromotor asymmetries (Sava, 2015). Additionally, recent applications in junior basketball athletes have demonstrated how MGM-15 detects dynamic changes in lower-limb control symmetry across different movement speeds (Iacobini & de Hillerin, 2025).

These examples underline the model's flexibility and diagnostic relevance in sport-specific contexts. However, despite its practical value, MGM-15 remains underrepresented in international literature. This suggests a gap between applied practice and academic validation.

Toward a Psycho-Neuro-Motor Assessment Paradigm

Addressing the conceptual limitations of traditional models, the MGM-15 protocol underpins a pioneering psycho-neuro-motor assessment framework, redefining vertical jump evaluation, through integrated biomechanical and neuromuscular perspective. The phrase "bouncing like a ball" is often used in jumping protocols to instruct athletes to minimize energy loss and maximize rebound, simulating the elastic properties of a ball. However, human movement differs from passive objects, as elastic rebound is modulated by active neuromuscular control (Struzik and Zawadzki, 2016).

While repetitive vertical jumps do involve a significant elastic component, the resulting average power output should not be interpreted solely as a reflection of mechanical or energetic capacity. Human performance is shaped by active neuromuscular mechanisms, including reflexive muscle activation, proprioceptive feedback and anticipation, which influence ground contact time, force and rhythm (Yilmaz et al., 2024; Botezatu et al., 2014; Kopper et al., 2013). These elements make the jump a functional proxy for psycho-neuro-motor quality rather than purely elastic recoil.

This perspective emphasizes the role of structural anticipation and coordinated neuromuscular control in movement execution (Botezatu et al., 2014). Considering this, motor performance assessment through repeated vertical jump tests should integrate the entire psycho-neuro-motor system, from central nervous system command to muscular response and feedback mechanisms (Geantă & de Hillerin, 2023).

Overall, within this integrative framework, the MGM-15 protocol provides a consistent, context-aware approach to evaluating repeated vertical jump performance, establishing itself as a promising tool for both athlete monitoring and inter-individual comparisons.

Limitations

This preliminary study is limited by a small and homogeneous sample, reducing the generalizability of its findings. The computational models were not validated against biomechanical gold standards such as force plates or 3D motion capture. Moreover, the simulated ball test, while illustrative, cannot replicate the complexity of human neuromuscular control. Therefore, the observed discrepancies should be interpreted with caution in applied contexts.

Conclusions

This study highlights the critical impact that computational methodology has on estimating average power output during repeated vertical jump testing. The Bosco, MG, and MGM-15 models yielded divergent results, confirming that these methods are not interchangeable. The MGM-15 model while, more conservative, offers a more comprehensive assessment by integrating neuromotor coordination, fatigue, and asymmetries.

This approach better reflects the psycho-neuro-motor complexity of human movement. Traditional models may overestimate power by neglecting elastic energy and control mechanism. Our findings underscore the need for standardized, integrative assessment protocols that combine mechanical and neuro-motor perspectives. Such tools are essential for accurate athlete profiling, reliable diagnostics, and individualized training strategies.

A paradigm shift is needed toward evaluation methods that reflect the full psycho-neuro-motor complexity of human performance. Standardized, integrative protocols like MGM-15 can bridge the gap between mechanical output and functional athletic capacity, improving both diagnostics and training personalization.

DOI 10.26773/mjssm.250910

Acknowledgment
We thank the participants for their voluntary involvement in this study.

Conflict of interests
The authors declare no conflicts of interest related to this study.

References
Akl, A. R. (2013). The role of biomechanical parameters and muscle activity during eccentric and concentric contractions in vertical jump performance. *Journal of Physical Education and Sport*, *13*(3), 430. https://doi.org/10.7752/jpes.2013.03069

Bojsen-Møller, J., & Magnusson, S. P. (2019). Mechanical properties, physiological behavior, and function of aponeurosis and tendon. *Journal of applied physiology (Bethesda, Md. : 1985)*, *126*(6), 1800–1807. https://doi.org/10.1152/japplphysiol.00671.2018

Bosco, C., Luhtanen, P., & Komi, P. V. (1983). A simple method for measurement of mechanical power in jumping. *European journal of applied physiology and occupational physiology*, *50*(2), 273–282. https://doi.org/10.1007/BF00422166

Botezatu, C. (2013). *Aspecte neuromusculare ale anticipării în pregătirea structurii corporale pentru contact, în performanța motrică* [Neuromuscular aspects of anticipation in preparing the body's structure for contact in motor performance] (Doctoral dissertation, Universitatea din Pitești). Universitatea din Pitești.

Botezatu, C., Andrei, C., & Hillerin, P. J. (2014). Neuromuscular Aspects of Anticipation in Preparing the Body for the Contact Structure in Motrice Performance. *Sport Science Review, 23*(1-2), 1-22. https://doi.org/10.2478/ssr-2014-0001

Ciobotaru, O., Voinescu, D., Ciobotaru, O., Ciocan, N. and Savu, C. (2014) "The Optimization of the Football Players' Agility Using the Data Provided by the Study of the Control Parameters by Means of the Modified Miron Georgescu Method", *Annals of "Dunarea de Jos" University of Galati. Fascicle XV, Physical Education and Sport Management*, 1, pp. 29-33. Available at: https://www.gup.ugal.ro/ugaljournals/index.php/efms/article/view/247

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences* (2nd ed.). Routledge. https://doi.org/10.4324/9780203771587

de Carvalho, A. R., Debastiani, J. C., Peyré-Tartaruga, L. A., & Bertolini, G. R. F. (2024). Estimated lower limb mechanical muscular power during vertical jumps by contact mat and bosco's equation: a correlation and agreement cross-sectional study. *Contribuciones A Las Ciencias Sociales*, *17*(1), 5222–5234. https://doi.org/10.55905/revconv.17n.1-311

Eythorsdottir, I., Gløersen, Ø., Rice, H., Werkhausen, A., Ettema, G., Mentzoni, F., Solberg, P., Lindberg, K., & Paulsen, G. (2024). The Battle of the Equations: A Systematic Review of Jump Height Calculations Using Force Platforms. *Sports medicine (Auckland, N.Z.)*, *54*(11), 2771–2791. https://doi.org/10.1007/s40279-024-02098-x

França, C., Marques, A., Ihle, A., Nuno, J., Campos, P., Gonçalves, F., Martins, J., & Gouveia, É. R. (2023). Associations between muscular strength and vertical jumping performance in adolescent male football players. *Human Movement*, 24(2), 94–100. https://doi.org/10.5114/hm.2023.117778

Fukashiro, S., Hay, D. C., & Nagano, A. (2006). Biomechanical behavior of muscle-tendon complex during dynamic human movements. *Journal of applied biomechanics*, *22*(2), 131–147. https://doi.org/10.1123/jab.22.2.131

García-Ramos, A., Janicijevic, D., Cobo-Font, J., Marcos-Frutos, D., Fernandes, J. F. T., Taube, W., & Pérez-Castilla, A. (2023). Knowledge of results during vertical jump testing: an effective method to increase the performance but not the consistency of vertical jumps. *Sports biomechanics*, *22*(7), 798–810. https://doi.org/10.1080/14763141.2020.1764090

Geantă, V. A., & de Hillerin, P. J. (2023). Assessment of motor skills by jump tests - Comparative analysis. In E. Balas, A. Roman, & D. Rad (Eds.), *Student's well-being and teaching-learning efficiency during post-pandemic period* (Vol. IV, pp. 249–271). Peter Lang.

Georgescu, M. (1953). Contribuții la studiul calităților fizice [Contributions to the study of physical qualities]. *Cultură fizică și sport*, *2*, 39–60.

Goecking, T., Holzer, D., Hahn, D., Siebert, T., & Seiberl, W. (2024). Unlocking the benefit of active stretch: the eccentric muscle action, not the preload, maximizes muscle-tendon unit stretch-shortening cycle performance. *Journal of applied physiology (Bethesda, Md. : 1985)*, *137*(2), 394–408. https://doi.org/10.1152/japplphysiol.00809.2023

Grădinaru, L., Mergheș, P., & Oravițan, M. (2024). The contribution of plyometric exercises assisted by sensory technology on vertical jump parameters in U15 female volleyball players. *Pedagogy of Physical Culture and Sports*, *28*(2), 156–167. https://doi.org/10.15561/26649837.2024.0210

Haseli, Y. (2020). *Entropy Analysis in Thermal Engineering Systems*. Academic Press. https://doi.org/10.1016/B978-0-12-819168-2.00001-5

Hillerin, P. J. (1997). *Despre proba Miron Georgescu modificată* [About the modified Miron Georgescu drill]. Republished internal use material.

Holt, N. C., & Mayfield, D. L. (2023). Muscle-tendon unit design and tuning for power enhancement, power attenuation, and reduction of metabolic cost. *Journal of biomechanics*, *153*, 111585. https://doi.org/10.1016/j.jbiomech.2023.111585

Iacobini, A. R., & de Hillerin, P. J. (2025). Case study on the dynamics of control asymmetry in ankle joint extension movement during psycho-neuro-motor control training. *Science, Movement and Health*, *25*(1), 36–42.

Kaufmann, S., Hoos, O., Beck, A., Fueller, F., Latzel, R., & Beneke, R. (2021). The Metabolic Relevance of Type of Locomotion in Anaerobic Testing: Bosco Continuous Jumping Test Versus Wingate Anaerobic Test of the Same Duration. *International journal of sports physiology and performance*, *16*(11), 1663–1669. https://doi.org/10.1123/ijspp.2020-0669

Kopper, B., Csende, Z., Sáfár, S., Hortobágyi, T., & Tihanyi, J. (2013). Muscle activation history at different vertical jumps and its influence on vertical velocity. *Journal of Electromyography and Kinesiology*, *23*(1), 132-139. https://doi.org/10.1016/j.jelekin.2012.09.005

Marin, C., de Hillerin, P. J., Marin, M., Vizitiu, C., Nistorescu, A., & Vizitiu, A. (2015). Arguments for a unified psycho-neuro-motor approach in Human Performance training. *Palestrica of the Third Millennium Civilization & Sport*, *16*(2).

Microgate. (n.d.). Home page: Microgate. Retrieved May 2, 2023, from https://www.microgate.it

Mierke C. T. (2022). Viscoelasticity, Like Forces, Plays a Role in Mechanotransduction. *Frontiers in cell and developmental biology*, *10*, 789841. https://doi.org/10.3389/fcell.2022.789841

Monroy, J. A., Lappin, A. K., & Nishikawa, K. C. (2007). Elastic properties of active muscle--on the rebound? *Exercise and sport sciences reviews*, *35*(4), 174–179. https://doi.org/10.1097/

jes.0b013e318156e0e6

Mureşan, A., Bulduş, C. F., & Grosu, V. (2016). The Control of Explosive Force Training in Volleyball Using MGM 15 Jumping Mat. *European Proceedings of Social and Behavioural Sciences*. http://dx.doi.org/10.15405/epsbs.2016.09.81

Natera, A. O., Chapman, D. W., Chapman, N. D., & Keogh, J. W. L. (2023). The reliability and validity of repeat power ability assessments and measurement indices in loaded vertical jumps. *PeerJ*, *11*, e15553. https://doi.org/10.7717/peerj.15553

Nishiumi, D., Nishioka, T., Saito, H., Kurokawa, T., & Hirose, N. (2023). Associations of eccentric force variables during jumping and eccentric lower-limb strength with vertical jump performance: A systematic review. *PloS one*, *18*(8), e0289631. https://doi.org/10.1371/journal.pone.0289631

Norton, R. L. (2013). *Design of machinery: An introduction to the synthesis and analysis of mechanisms and machines* (5th ed.). McGraw-Hill Education.

Roberts, T. J. (2016). Contribution of elastic tissues to the mechanics and energetics of muscle function during movement. *Journal of Experimental Biology*, 219(2), 266–275. https://doi.org/10.1242/jeb.124446

Roberts, T. J., & Konow, N. (2013). How tendons buffer energy dissipation by muscle. *Exercise and sport sciences reviews*, *41*(4), 186–193. https://doi.org/10.1097/JES.0b013e3182a4e6d5

Satkunskiene, D., Kamandulis, S., Brazaitis, M., Snieckus, A., & Skurvydas, A. (2021). Effect of high-volume stretch-shortening cycle exercise on vertical leg stiffness and jump performance. *Sports Biomechanics, 20*(1), 38–54. https://doi.org/10.1080/14763141.2018.1522366

Sava, M. A. (2015). Study Regarding The Manifestation Of The Explosive Force To Judoka Aged 14-16 Years. *Gymnasium*, *16*(2). Available at: https://gymnasium.ub.ro/index.php/journal/article/view/143

Shahsavari, S., & Torkaman, P. (2022). Energy Conservation Principle from the Perspective of the Energy Structure Theory. *Asian J. Appl. Sci*, *10*(5).

Struzik, A., & Zawadzki, J. (2016). Application of force-length curve for determination of leg stiffness during a vertical jump. *Acta of bioengineering and biomechanics*, *18*(2), 163–171.

Sozbir, K., Willems, M. E., Tiryaki-Sonmez, G., & Ragauska, P. (2016). Acute effects of contract-relax PNF and static stretching on flexibility, jump performance and EMG activities: A case study. *Biology of Exercise*, *12*(1), 33-55. https://doi.org/10.4127/jbe.2016.0099

Wu, D. T., Jeffreys, N., Diba, M., & Mooney, D. J. (2022). Viscoelastic Biomaterials for Tissue Regeneration. *Tissue engineering. Part C, Methods*, *28*(7), 289–300. https://doi.org/10.1089/ten.TEC.2022.0040

Yilmaz, O., Soylu, Y., Erkmen, N., Kaplan, T., & Batalik, L. (2024). Effects of proprioceptive training on sports performance: a systematic review. *BMC sports science, medicine & rehabilitation*, *16*(1), 149. https://doi.org/10.1186/s13102-024-00936-z

DOI 10.26773/mjssm.250910