Journal Coaching Education Sports
Vol. 7, No.2, Agust 2026, pp. 409-417
E-ISSN: 2722-3450 P-ISSN: 2775-3808

A Locally Manufactured Laser Gate was Employed to Assess the Agility of College Volleyball Players.

Muhammad Syaleh [1*], Agung Nugroho[2], Muhammad Eka Mardyansyah Simbolon[3], Dzihan Khilmi Ayu Firdausi[4], Fredy Eko Setiawan [5]

[1,2] Department of Physical Education, Sekolah Tinggi Olahraga dan Kesehatan Bina Guna, Jl. Aluminium Raya No.77 Tanjung Mulia, Medan Deli

[3,4]Department of Physical Education, Universitas Muhammadiyah Bangka Belitung, Jl. K.H. Ahmad Dahlan KM 4, RT.03 No.51, Keramat, Kec. Rangkui, Kota Pangkalpinang, Kepulauan Bangka Belitung 33134

[5] Department of Sports Science, Universitas Ngudi Waluyo, Jl. Diponegoro No. 186, Candirejo, Ungaran Barat, Kabupaten Semarang, Jawa Tengah, kode pos 50513

e-mail: msyaleh3@gmail.com[1], agung_nugroho@student.uns.ac.id[2], simbolon@unmuhbabel.ac.id[3] , dzihanayu@unmuhbabel.ac.id[4] ,fredy@unw.ac.id[5]

Abstract

Introduction: Agility is essential in volleyball. Accurate measurement helps identify talent, improve training, and reduce injury risk. However, common methods such as the T-agility test have limits in accuracy and practicality. Therefore, sensor-based technologies are developed to provide more objective and precise results. **Objective:** This study aims to create a low-cost and practical sensor system to measure volleyball agility. It focuses on developing a laser-based timing gate and evaluating its validity and reliability within a single session. **Methodology:** The participants were 25 collegiate volleyball players (age: 19.0 ± 0.88 years; height: 161.9 ± 7.19 cm; weight: 53.6 ± 9.15 kg). Each participant performed the T-test twice, and the average score was used for analysis. Intra-session reliability was assessed using the Intraclass Correlation Coefficient (ICC). **Results:** The laser timing system showed slightly faster results than the stopwatch in the first trial, slower results in the second, and overall faster average times across trials. **Discussion:** A low-cost laser-based agility system was successfully developed and tested against a manual stopwatch. The findings indicate acceptable validity and reliability. Faster times from the laser system are likely due to the removal of human reaction delays. This system is affordable, simple to use, and suitable as an alternative to expensive commercial timing devices, allowing wider access to objective performance measurement. **Conclusions**: The laser timing gate is a reliable and economical tool for assessing agility in volleyball players and is useful for research and training purposes.

Keywords: Change of direction, Wearable sensor, Timing gate, Agility, Volly ball athlete’s

corresponding author: msyaleh3@gmail.com
Artikel Info:
Submitted: **26/04/2026** Revised: **29/04/2026** Accepted: **15/07/2026** Published: **24/07/206**

How to Cite: Saleh, M., Nugroho, A., DSSimbolon, M, E, M., Firdausi, D, K, A., Dsetiawan, F, E.. (2026). A Locally Manufactured Laser Gate was Employed to Assess the Agility of College Volleyball Players. *Journal Coaching Education Sports*, 7(2), 409-417.
Author’s Contribution: a) Desain Penelitian; b) Pengumpulan Data; c) Analisis Statistik; d) Penyusunan Naskah; e) Pengumpulan Dana

A. Introduction

Agility is the foundation of volleyball performance, enabling quick changes of direction, explosive movements, and effective responses to unexpected game situations. In volleyball, agility is one of the most important skills to possess (Muchlisin & Pasaribu, 2025). Accurate agility measurements are essential for identifying talent, optimizing training, and preventing injuries. The shift from traditional field tests to advanced computerized and sensor-based systems reflects the growing demand in sports for objective, reliable, and actionable data (Matkarimov et al., 2024)(Pocek et al., 2020)(Ye et al., 2025). However, challenges remain in ensuring that these methods are accessible, valid across various populations, and integrated with physiological and biomechanical insights. Measurements of agility in volleyball players encompass a variety of methodologies, ranging from traditional running and shuttle tests to advanced computerized systems that utilize sensors and real-time feedback devices. The Agility T-test is a widely used measure of agility in volleyball players, particularly for male athletes (Pramono et al., 2023), and female athletes as well (Bassa et al., 2024). Previous research (Mejía et al., 2024) Measuring agility using the T-test still traditionally relies on a stopwatch. However, this traditional method of measurement using a stopwatch is highly prone to producing low accuracy and consistency (Arief et al., 2023). Other studies have used timing-gate technology to prevent this (Erol et al., 2025)(Gandouzi et al., 2025). The results of the study indicate that instruments with a high level of validity are capable of producing more accurate and consistent data (Candra et al., 2025). Although this system offers objectivity, reliability, and a wealth of data, there are still challenges regarding accessibility, cost, and validation for adult professional athletes and athletes with disabilities (Li & Ji, 2021)(Lima et al., 2021)(Rebelo, 2022)(Steff et al., 2024).

Ongoing research and innovation are needed to bridge the gaps in test validation and the accessibility of laser gate technology. We aim to develop a low-cost, scalable sensor-based system to ensure broader accessibility. This initiative aims to ensure that agility measurements support the development and performance optimization of volleyball athletes at all levels and across all populations. Therefore, this study aims to: (i) develop and validate a laser-based timing gate to improve ecological validity, (ii) determine criterion validity by establishing the relationship between laser gate scores and traditional measurements, and (iii) test the absolute and relative intra-session reliability of the laser gate.

B. Methods

Participants

Twenty-five (11 males and 14 females) students from the Health and Recreation Physical Education program volunteered to participate (Table 1). The inclusion criteria for students were: 1) not currently experiencing injury or major pathology in the ankle, knee, or hip; 2) playing volleyball for more than three hours per week; and 3) currently physically active. Participants were asked to learn the T-test agility procedure and perform the trial at least twice before data collection. Once they understood the procedure for the agility T-test, each participant wore athletic shoes during data collection. Ethical approval for this study regarding the procedures and equipment was obtained from the review boards of STOK Bina Guna and Muhammadiyah University of Bangka Belitung, and all participants understood and verbally agreed that data collection was conducted for research purposes.

Laser gate system

The sensor hardware consists of two laser transmitter sensors (Figure 1a) and a laser receiver (Figure 1b) that function as a start/stop timer. The developed technological components are integrated into the sensor hardware design. After the basic principles were studied, the implementation of a Bluetooth-enabled display (Figure 1c) facilitates communication between the sensor device and the display. Predictions regarding the capabilities of the technological elements have been validated through modeling and simulation. Laboratory experiments have confirmed the feasibility of the laser gate device. All devices have been approved by the institutional review boards of STOK Bina Guna and Muhammadiyah University of Bangka Belitung and labeled as devices with insignificant risk.

Figure 1. Manufacturing of laser gate devices.

Experimental environment

The device was tested in the auditorium of Muhammadiyah University of Bangka Belitung (Figure 2). The ‘T’-shaped pattern from the agility T-test used in a previous study was employed in this study (Steff et al., 2024). Laser gate sensors, mounted approximately 0.83 m above the ground, are positioned on either side of the start/finish line, 3 m apart. Examiners are stationed on the start/finish line.

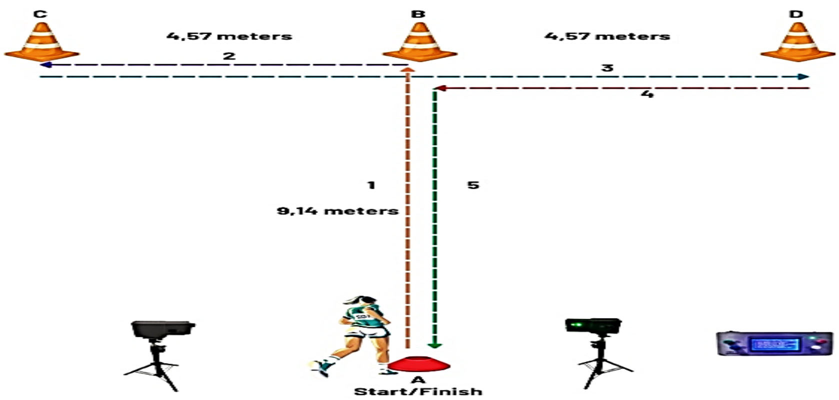

Figure 2. The experimental setup includes the layout of the laser gate apparatus.

Agility T-test protocol

The protocol for conducting the agility T-test, as described by (Ho et al., 2019)(Steff et al., 2024)(Gandouzi et al., 2025), The subject traveled a total of 36.56 m during the change of running direction. The subject faced forward throughout the entire run. As shown in Figure 2, the subject started at the first cone (A), ran forward 9.14 m, and touched the second cone (B) with their right hand. Then, they sidestepped 4.57 m to the left to the third cone (C) and touched it with their left hand. From the third cone, the subject sidestepped 9.14 m to the right to the fourth cone (D), touched it with their right hand, and then sidestepped 4.57 m back to the second cone (B) and touched it with their left hand. Finally, the subject runs backward to the starting position (A). The total time for the four-directional change of direction (CODS) is recorded by a laser gate device and a stopwatch operated by an experienced examiner. In this study, each subject performed two trials, and the average of the two trials was taken as the result.

Data análisis

Jamovi software (version 2.6.23.0) was used for all statistical analyses. Means and standard deviations were calculated after verifying the normality of the distribution using the Shapiro-Wilk statistic. Effect size estimates (ES), mean differences, and 95% confidence intervals (CI) were calculated. Criterion-related validity analysis was conducted by calculating the Pearson correlation (r) between the test scores. A paired t-test was used to evaluate the equivalence of the final results from the two trials. Intra-session relative reliability was determined by calculating the Intraclass Correlation Coefficient (ICC). Absolute intra-session reliability was examined using a Bland-Altman plot, and systematic bias ± random error was assessed using 95% limits of agreement (LOA). Significance for all statistical tests was set at $p < 0.05$.

C. Result and Discussion

Result

All sets of measurement data obtained using the laser gate and stopwatch in each trial were normally distributed (p = 0.073–0.666). The mean measurement results for the first trial using the laser gate were faster than those obtained using the stopwatch (14.5 ± 1.80 vs. 14.9 ± 1.71). The mean measurement result in the second trial using the laser gate was slower than that using a stopwatch (13.8 ± 1.71 vs 13.7 ± 1.51). The mean total measurement result from the first and second trials using the laser gate was faster than that using a stopwatch (14.2 ± 1.58 vs 14.3 ± 1.53). The results of this analysis are presented in Table 1.

Table 1. Descriptive statistics and normality assessment

			95% CI			Shapiro-Wilk	
	M	SD	Lower	Upper	SE	W	p
TG1	14.5	1.800	13.8	15.3	0.360	0.927	0.073
TG2	13.8	1.710	13.1	14.5	0.342	0.956	0.335
TGA	14.2	1.584	13.5	14.8	0.317	0.935	0.115
S1	14.9	1.710	14.2	15.6	0.342	0.971	0.666
S2	13.7	1.518	13.1	14.4	0.304	0.969	0.617
SA	14.3	1.537	13.7	14.9	0.307	0.964	0.495
Age	19.0	0.889	18.6	19.3	0.178	0.759	<.001
Height	161.9	7.193	159.0	164.9	1.439	0.931	0.093
Weight	53.6	9.152	49.8	57.3	1.830	0.864	0.003

Note. CI = Confidence Interval; M = Mean; S1 = Stopwatch trial 1; S2 = Stopwatch trial 2; SA = Stopwatch total; SE = Std. Error of Mean; SD = Std. Deviation; TG1 = Timming gate trial 1; TG2 = Timming gate trial 2; TGA = Timming gate total

Pearson's correlation coefficients were calculated to analyze criterion validity (Table 2) between the tests administered, laser gate timing versus stopwatch timing for each trial and the total, as well as between the trial times of each test and the laser gate and stopwatch timing. The results showed "strong" to "very strong" significant correlations. The criterion validity correlations revealed very strong relationships between the two measurement methods for each trial as well as the total measurement results. Specifically, TG1 with S1 (r = 0.956), TG2 with S2 (r = 0.746), and TGA with SA (r = 0.922), supporting construct validity. Very strong correlations were also found between trials using laser gate timing: between TG1 and TG2 (r = 0.631), TG1 and TGA (r = 0.908), and TG2 and TGA (r = 0.898). Similarly, strong correlations were found between trials in stopwatch measurements: between S1 and S2 (r = 0.816), S1 and SA (r = 0.959), and S2 and SA (r = 0.947).

Table 2. Analysis of the correlation between the test trial

	TG1	TG2	TGA	S1	S2	SA
TG1	—					
TG2	0.631***	—				
TGA	0.908***	0.898***	—			
S1	0.965***	0.617**	0.881***	—		
S2	0.833***	0.746***	0.876***	0.816***	—	
SA	0.947***	0.711***	0.922***	0.959***	0.947***	—

Note. * p < .05; ** p < .01; *** p < .001.

The absolute and relative inter-trial reliability indices are presented in Table 3. Reliability assessment followed a hierarchical evaluation: relative reliability (ICC) determines the degree of consistency. An ICC value ≥ 0.70 indicates acceptable reliability. A paired t-test evaluating the equivalence of the final results from two agility trials showed no significant difference (p = 0.252). A Bland-Altman plot (Figure 3) was constructed, with ±95% LOA, for inter-rater reliability within each session and mean test-retest reliability.

Table 3. Inter-trial reliability and equivalence analysis.

	ICC (95%)	Agreement	t	p	Effect Size
TG1-S1	0.964 (0.916-0.985)	0.946	-3.70	0.001	-0.741
TG2-S2	0.741 (0.580-0.943)	0.748	0.260	0.797	0.052
TGA-SA	0.921 (0.863-0.988)	0.920	-1.17	0.252	-0235
TG1-TG2	0.630 (0.419-0.781)	0.590	1.38	0.026	0.475
S1-S2	0.810 (0.482-0.834)	0.656	5.66	<.001	1.13

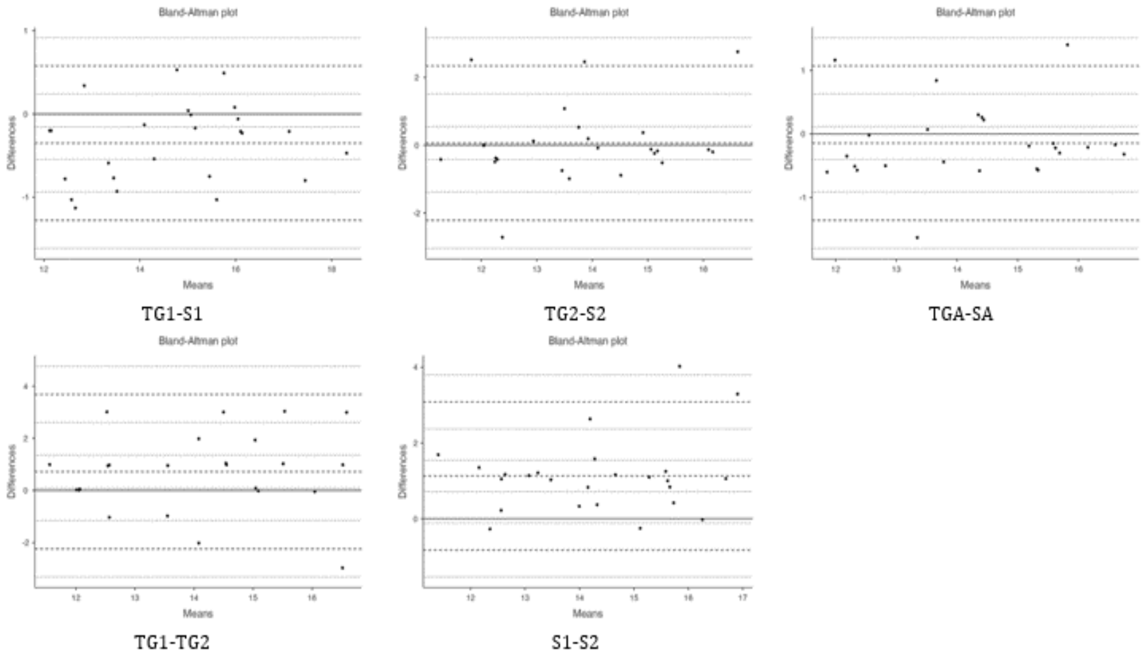

Figure 3. Bland-Altman plots inter-raters each sessions and mean test-retest.

Discussion

This study aimed to develop and validate a low-cost sensor-based agility measurement system using a laser timing gate and to examine the criterion validity and intra-session reliability compared to a conventional stopwatch during the T-agility test in college volleyball players. The findings indicate that the laser-based timing system produced measurement results that differed slightly from the manual stopwatch across all trials, with faster times recorded in the first trial and the overall average, and slower times observed in the second trial. Sensor-based measurements tend to offer higher accuracy and reliability compared to traditional stopwatch methods in various applications, including walking speed, running speed, reading speed, and athletic performance. However, the choice of measurement tools must consider the specific context and the required precision.

The observed discrepancy between laser gate measurements and stopwatch readings is consistent with previous research highlighting the inherent limitations of manual timing methods (Bricker et al., 2016)(Dewanti & Hermawan, 2022)(Cleland et al., 2023). Stopwatch-based measurements rely heavily on human reaction times, which can introduce systematic and random errors, particularly in short-duration, high-intensity tasks such as agility tests. In contrast, laser-based timing systems automatically start and stop the timing upon beam interruption, thereby reducing human-related variability and enhancing measurement objectivity. The faster average times recorded by the laser gate in the first trial and across all trials may reflect the elimination of delayed manual triggering typically associated with stopwatch use. Interestingly, the second trial yielded slower measurements with the laser gate compared to the stopwatch. This variation may be due to factors such as movement initiation strategies, body position relative to the laser beam, or minor inconsistencies that constitute potential inaccuracies in manual measurements (Radner et al., 2017). These findings underscore the sensitivity of sensor-based systems to precise movement mechanics, which, while potentially improving measurement accuracy, may also amplify inconsistent performance variations that can be captured by manual timing measurements. The consistency of laser gate measurements across repeated trials demonstrates satisfactory intra-session reliability, reinforcing its suitability for repeated performance monitoring. Accurate agility assessments help in adjusting training loads to optimize performance and prevent injuries (Rebelo et al., 2025; Timoteo et al., 2025). Reliable measurements are crucial in the context of volleyball, where agility performance is often assessed to inform adjustments to training loads, talent identification, and injury prevention strategies.

This study demonstrates that the development of low-cost, scalable sensor-based solutions is entirely feasible. High-end commercial timing systems are often prohibitively expensive and out of reach for many educational institutions and sports programs, particularly in developing regions. The proposed laser-based system offers a practical alternative that balances affordability with acceptable measurement accuracy and reliability, thereby expanding access to objective performance assessment technology. Nevertheless, this study has several limitations. The study's sample size is relatively small and limited to college volleyball players, which may restrict the generalizability of the findings to other populations or sports. Furthermore, this study focused solely on the T-agility test; future research should examine the system's application across various agility protocols and movement patterns. Further validation against gold-standard motion capture systems or high-speed camera systems would also strengthen the evidence of measurement accuracy.

D. Conclusion

The findings of this study indicate that the laser-based timing gate system developed provides an objective, reliable, and cost-effective method for assessing agility performance in volleyball players. Although there were slight differences compared to stopwatch measurements, the overall results support the criterion validity and practical utility of the system. The adoption of such sensor-based systems can enhance the quality of performance assessment in sports science research and applied training settings.

E. Acknowledgments

The author would like to express gratitude to the Directorate of Research and Community Service (DPPM) of the Ministry of Higher Education, Science, and Technology of the Republic of Indonesia for providing a research grant under the Early-Career Faculty Research Scheme, contract number 122/C3/DT.05.00/PL/2025. The author also extends gratitude to the Research and Community Service Institute (LPPM) of the Bina Guna College of Sports and Health and the Physical Education and Health Education (PJKR) Program at Muhammadiyah University of Bangka Belitung for their support and facilitation of this research. Special thanks are also extended to the Bangka Tengah Regency Sports Council (KONI) for its support in this study.

References

Arief, N. A., Nugraha, T. A., Gede Agung Sri Sidhimantra, I., Anwar, S., Umaroh, S. T., & Asmara, Y. P. (2023). Application of alacrity as a means to improve athlete's agility. In S. N., P. B.K., S. M., & T. H.P.A. (Eds.), *E3S Web of Conferences* (Vol. 450). EDP Sciences. https://doi.org/10.1051/e3sconf/202345002007

Bassa, E., Lola, A. C., Melliou, A., Prassa, M., Stavropoulou, G., & Ziogas, N. (2024). Agility Ladder Training Combined With Plyometric or Multidirectional Speed Drills: Short-Term Adaptations on Jump, Speed, and Change of Direction Performance in Young Female Volleyball Players. *Pediatric Exercise Science*, *36*(4), 248–257.

https://doi.org/10.1123/pes.2024-0024

Bricker, J. C., Bailey, C. A., Driggers, A. R., McInnis, T. C., & Alami, A. (2016). A New Method for the Evaluation and Prediction of Base Stealing Performance. *Journal of Strength and Conditioning Research*, *30*(11), 3044–3050. https://doi.org/10.1519/JSC.0000000000001394

Candra, J., Indrayana, B., Sagala, R. S., & Daulay, D. E. (2025). Making an Electric Vertical Jump Limb Muscle Explosiveness Test Tool Using Iot Technology in Physical Education Activities. *Sports Education Coaching Journal*, *6*(1), 60–69. https://doi.org/10.31599/jces.v6i1.3467

Cleland, B. T., Alex, T., & Madhavan, S. (2023). Concurrent validity of walking speed measured by a wearable sensor and a stopwatch during the 10-meter walk test in individuals with stroke. *Gait and Posture*, *107*, 61–66. https://doi.org/10.1016/j.gaitpost.2023.09.012

Dewanti, R. A., & Hermawan, I. (2022). A comparative study on measuring running speed using timing gates and stopwatches to reduce human error. *Journal of Physical Education and Sport*, *22*(12), 3080–3085. https://doi.org/10.7752/jpes.2022.12390

Erol, M., Girginer, F. G., Seyhan, S., Acar, G., Cerit, G., Uzun, M., & Soylu, C. (2025). Predicting injury risk in young female volleyball players through movement and jump assessments. *Frontiers in Public Health*, *13*. https://doi.org/10.3389/fpubh.2025.1658046

Gandouzi, I., Dhahbi, W., Ghouili, H., Bougrine, H., Guelmami, N., Weiss, K., Rosemann, T., Dergaa, I., Knechtle, B., & Abderrahman, A. B. (2025). The team agility plus test: A novel three-dimensional approach for assessing agility in multidirectional sports. *Journal of Bodywork and Movement Therapies*, *45*, 215–224. https://doi.org/10.1016/j.jbmt.2025.08.021

Ho, C.-S., Lin, K.-C., Hung, M.-H., Chang, C.-Y., & Chen, K.-C. (2019). System design and application for evaluation of digging agility in college male volleyball players. *Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology*, *233*(3), 424–431. https://doi.org/10.1177/1754337119840837

Li, B., & Ji, G. (2021). Value Analysis of Video Image Multiprocessing Based on Vision Sensor in the Field of Football Scientific Research. *Journal of Sensors*, *2021*. https://doi.org/10.1155/2021/9738380

Lima, R., Rico-González, M., Pereira, J., Caleiro, F., & Clemente, F. (2021). Reliability of a reactive agility test for youth volleyball players. *Polish Journal of Sport and Tourism*, *28*(1), 8–12. https://doi.org/10.2478/pjst-2021-0002

Matkarimov, R., Tajibaev, S., Astuti, Y., Toshpulatov, K., Ismoilov, G., Mamajonov, D., Khojiev, S., & Khasanov, A. (2024). Enhancement of a software–hardware system for measuring volleyball players' speed indicators and evaluating its effectiveness in a pedagogical context. *Journal of Physical Education and Sport*, *24*(9), 1194–1208. https://doi.org/10.7752/jpes.2024.09244

Mejía, N. F. M., Funez, C. R., Zelaya, A. M. S., Bonilla, J. E. L., Marín, A. R., & Alvarado, A. S. (2024). Association between power and change of direction in men's college volleyball. *Retos*, *51*, 1070–1075. https://doi.org/10.47197/RETOS.V51.100560

Muchlisin, A., & Pasaribu, N. (2025). The Effect of Plyometric Training Program on Increasing Vertical Jump Ability in Volleyball Players. *Journal Coaching Education Sports*, *6*(1), 1–8. https://doi.org/10.31599/jces.v6i1.1950

Pocek, S., Vukovic, J., Jaksic, D., Lakicevic, N., Messina, G., Bianco, A., & Drid, P. (2020). Fitness profile of young female volleyball players. *Medicina Dello Sport*, *73*(2), 197–209. https://doi.org/10.23736/S0025-7826.20.03698-4

Pramono, H., Rahayu, T., & Yudhistira, D. (2023). THE EFFECT OF PLYOMETRICS EXERCISE THROUGH AGILITY LADDER DRILL ON IMPROVING PHYSICAL ABILITIES OF 13–15-YEAR-OLD VOLLEYBALL PLAYERS. *Physical Education Theory and Methodology*, *23*(2), 199–206. https://doi.org/10.17309/tmfv.2023.2.07

Radner, W., Diendorfer, G., Kainrath, B., & Kollmitzer, C. (2017). The accuracy of reading speed measurement by stopwatch versus measurement with an automated computer program (rad-rd©). *Acta Ophthalmologica*, *95*(2), 211–216. https://doi.org/10.1111/aos.13201

Rebelo, A. (2022). Absolute Reliability, Relative Reliability, and Criterion-Related Validity of Two Reactive Agility Tests Using Two Types of Stimuli in Elite Male Volleyball Players. *Polish Journal of Sport and Tourism*, *29*(2), 24–29. https://doi.org/10.2478/pjst-2022-0011

Rebelo, A., Pereira, J. R., Nakamura, F. Y., & Valente-dos-Santos, J. (2025). Beyond the Jump: A Scoping Review of External Training Load Metrics in Volleyball. *Sports Health*, *17*(1), 111–125. https://doi.org/10.1177/19417381241237738

Steff, N., Badau, D., & Badau, A. (2024). Improving Agility and Reactive Agility in Basketball Players U14 and U16 by Implementing Fitlight Technology in the Sports Training Process. *Applied Sciences (Switzerland)*, *14*(9). https://doi.org/10.3390/app14093597

Timoteo, T. F., Debien, P. B., Fonseca, D. S., Felício, D. C., & Bara Filho, M. G. (2025). Training Load and Injuries in Volleyball: An Approach Based on Different Methods of Calculating Acute to Chronic Workload Ratio. *Sports Health*, *17*(1), 104–110. https://doi.org/10.1177/19417381241293771

Ye, J., Cheng, R., Gao, B., Wang, Y., & Wang, Y. (2025). Scientific Assessment of Agility Performance in Competitive Sports: Evolution, Application, Reliability, and Validity. *Strength and Conditioning Journal*, *47*(1), 56–75. https://doi.org/10.1519/SSC.0000000000000862