

# The effect of a 4-week plyometric training exercise on specific physical fitness components in U21 novice volleyball players

Jet Longakit<sup>1ABCDE</sup>, Felix M. Aque Jr.<sup>1BCDE</sup>, Lyndie Toring-Aque<sup>1BCDE</sup>, Joseph Lobo<sup>2ACDE</sup>,  
Novadri Ayubi<sup>3ACDE</sup>, Ranel Mamon<sup>4ABCD</sup>, Lloyd Coming<sup>5ABCD</sup>, Desiree Kate Padilla<sup>6ABCD</sup>,  
Christian Alex Mondido<sup>7ABCD</sup>, Jay Mark Sinag<sup>8ABCD</sup>, Vlad Adrian Geanta<sup>9ABCD</sup>,  
Swamynathan Sanjaykumar<sup>10ABCD</sup>

<sup>1</sup> College of Education, Department of Physical Education, MSU-Iligan Institute of Technology, Philippines

<sup>2</sup> College of Sports, Exercise and Recreation, Bulacan State University, Philippines

<sup>3</sup> Universitas Negeri Surabaya, Indonesia

<sup>4</sup> College of Teacher Education, Central Mindanao Colleges, Philippines

<sup>5</sup> Department of Teacher Education, Kolehiyo ng Pantukan, Philippines

<sup>6</sup> Bukidnon State University, Philippines

<sup>7</sup> Institute of Human Kinetics, Rizal Technological University, Philippines

<sup>8</sup> Bataan Peninsula State University, Philippines

<sup>9</sup> Faculty of Physical Education and Sport, Aurel Vlaicu University of Arad, Romania

<sup>10</sup> Department of Physical Education and Sports, Sree Sankaracharya University of Sanskrit, India

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

## Abstract

**Background and Study Aim** Plyometric training is widely utilized to improve athletic performance by increasing explosive power, speed, and agility. Despite extensive research on its benefits for professional athletes, there is a lack of empirical studies investigating how plyometric exercise training influences specific fitness components in novice volleyball players. This study aimed to investigate the impact of a 4-week plyometric training program on particular physical fitness components in novice volleyball players under 21 years of age.

**Material and Methods** This study involved 40 novice volleyball players under 21 years of age ( $M = 19.28 \pm 0.93$  years). Participants were randomly assigned to an experimental group ( $n = 20$ ), which engaged in an organized 4-week plyometric training program, or a control group ( $n = 20$ ), which adhered to their conventional training schedule. Performance in lateral cone hops, burpees, squat jumps, box jumps, and a 40-meter sprint was evaluated through pre- and post-test assessments. Data were analyzed using paired and independent samples t-tests, with a significance threshold of  $p < 0.05$ .

**Results** The results showed substantial enhancements in all assessed training metrics for the experimental group relative to the control group. Significant improvements were noted in lateral cone hops, squat jumps, and sprint performance. The results indicate that short-term plyometric training markedly improves specific fitness components essential for volleyball performance.

**Conclusions** A four-week plyometric training program significantly enhances particular fitness components in U21 novice volleyball players. These findings underscore the need to include plyometric exercises in training programs to improve athletic performance. Future studies should investigate the long-term effects and adaptations across various levels of athletes.

**Keywords:** plyometric training, volleyball, physical fitness, exercise training

## Introduction

The utilization of the plyometric method in the preparation of athletes, including volleyball players, has garnered significant attention from numerous authors. Plyometric exercises entail explosive movements that focus on a quick muscular stretch followed by a vigorous contraction [1, 2]. This training method is advantageous for improving speed, strength, and dexterity in players, rendering

it crucial for sports [3, 4, 5]. Research demonstrates that plyometric activities can substantially enhance athletic performance by augmenting muscle strength, refining balance and coordination, and improving cardiovascular fitness [6, 7, 8, 9]. Moreover, various studies indicate that athletes participating in plyometric training exhibit significant enhancements in explosive power, correlating with elevated performance levels in competitions [10, 11, 12]. The components of physical fitness are essential for athletic performance, and plyometric training is fundamental for enhancing these qualities. Despite extensive research on the benefits of plyometric

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exercises for athletic performance, there is limited empirical evidence regarding its targeted effects on specific components of physical fitness, particularly among novice volleyball players in the under-21 (U21) category.

Plyometric training is an efficient method that stresses the musculotendinous unit [13, 14] and improves vertical jump height [15, 16, 17], as noted by Silva et al. [1], who documented enhancements ranging from 4.7% to 15% with bodyweight exercises, including countermovement, depth, and squat jumps. This training technique markedly improves neuromuscular coordination by activating the neural system and refining the stretch-shortening cycle (SSC), which entails an immediate transition from muscle extension to contraction [11, 18]. Plyometric training also develops flexibility [19, 20], augments the storage of elastic energy in muscles [21, 22], engages additional muscle units [23, 24], increases neuronal firing frequency [25], and improves joint proprioception [26, 27]. Multiple studies validate the advantages of integrating plyometrics into strength training programs, emphasizing enhancements in proprioception, acceleration, leg strength, muscle power, and jumping performance [28, 29, 30]. Consequently, a study by Huang et al. [11] underscores the significance of plyometric workouts in attaining optimal athletic performance when combined with structured strength training.

For volleyball players, the capacity to execute forceful jumps is essential for performing skills such as spiking and blocking [31, 32, 33]. Research indicates that athletes participating in plyometric training exhibit significant enhancements in explosive power, correlating with elevated performance levels in competitions [10, 20, 34]. Furthermore, athletes exhibiting greater explosive power have demonstrated a 20% increase in competition performance, underscoring the need for specialized training [35, 36]. A carefully developed plyometric exercise program may increase neuromuscular efficiency, enabling athletes to produce greater ground reaction forces and accelerate more rapidly on the court [27, 34]. Hence, incorporating progressive workouts into a training regimen helps athletes build a solid foundation of strength, speed, and agility, ultimately translating into better on-court performance [37, 38]. Through gradual progression and careful attention to technique, players can safely improve their athletic capabilities and prepare for the demands of the sport [20, 30].

Consequently, integrating progressive workouts into a training routine aids athletes in establishing a robust foundation of strength, speed, and agility, which eventually enhances on-court performance [24, 36]. By applying gradual improvements and maintaining precise dedication to technique, athletes can securely enhance their physical

abilities and prepare themselves for the demands of the sport [30, 39].

Previous studies have primarily focused on experienced or elite athletes, neglecting how plyometric training might influence physical fitness development in novice athletes who are still in the early stages of their performance trajectory. Additionally, there is a lack of studies employing short-term intervention programs, such as a 4-week plyometric training regimen, to evaluate their effectiveness on volleyball-specific physical fitness attributes. Hence, this study bridges the gap by investigating the effects of a 4-week plyometric training program on targeted physical fitness components specifically in U21 novice volleyball players. Unlike existing research, this study focuses on a relatively underexplored population and employs a condensed training duration, offering insights into the feasibility and efficiency of short-term plyometric interventions. Furthermore, the study emphasizes volleyball-specific physical fitness components, contributing valuable knowledge to the optimization of training protocols for novice athletes in this sport.

## Methods and Materials

### *Participants*

The participants in this study were volleyball players with at least two years of experience in sports participation. The study involved 40 volleyball players aged 19 to 21 years ( $M = 19.28$ ,  $SD = 0.93$ ) who were recruited for this investigation. The inclusion criteria included: (1) the player had to be under 21 years old, (2) at least one to two years of sports experience, and (3) no reported injuries in the last three months. Individuals with disabilities, immunocompromised conditions, or a history of cardiovascular difficulties were excluded from testing due to their unique health needs. The detailed characteristics of the participants are shown in Table 1.

### *Procedure*

This study adhered to ethical guidelines prior to the commencement of the experiment. All participants were notified of the study's objective, and informed consent was obtained from every participant. Additionally, the researchers explained the benefits of the study to the institution, community, and its contribution to scientific knowledge. Moreover, respondents were notified that the data obtained would no longer be used in any subsequent or secondary research. Withdrawal of respondents' participation in the study would not have any adverse effects on their relationships with the involved researchers or research organizations, nor would it affect their contributions to any future services or current programs. In order to maintain the anonymity and confidentiality of the respondents,

**Table 1.** Characteristics of the participants

Group	Experimental M ± SD	Control M ± SD	Total M ± SD
Age (years)	19.30 ± .84	19.25 ± 1.02	19.28 ± .93
Height (cm)	168.10 ± 4.16	169.13 ± 3.64	168.62 ± 3.95
Weight (kg)	47 ± 1.14	46.70 ± 1.03	46.85 ± 3.95
BMI (kg/m <sup>2</sup> )	16.66 ± .82	16.35 ± .95	16.51 ± .89

their identities and names were withheld throughout the data collection, analysis, and reporting of the study’s findings. Due to the aforementioned conditions, respondents were permitted to withdraw from the study at any time or request a debriefing. All respondents’ information was securely protected in accordance with the Data Privacy Act of 2012.

Each participant completed a brief questionnaire regarding their personal information and history of sports-related injuries. No participants were rejected from the study, as none exhibited issues that justified exclusion based on the results. An experimental design incorporated pre- and post-assessments to evaluate athletic performance. The control group received standard basic training program instructions, whereas the experimental group engaged in a 4-week plyometric training program aimed at improving player performance through targeted fitness components. Plyometric training exercises were performed to assess the athletes’ fitness and improvement in physical performance: (1) lateral cone hops, (2) burpees, (3) squat jumps, (4) box jumps, and (5) 40-meter sprints. Subsequently, novice volleyball players from both groups engaged in a 4-week plyometric workout routine under similar conditions, encompassing facility usage and environmental factors.

*Execution of Plyometric Training Exercise*

*Lateral Cone Hops:*

- a. Target fitness components: Agility and lateral power.
- b. Benefits: Enhances quick lateral movements essential for volleyball, improving agility and balance. Develops lower-body explosive power and responsiveness.
- c. Execution: Place a cone on the ground and assume a stance to one side with your feet shoulder-width apart. Slightly bend your knees, adopting an athletic posture while engaging your core. Propel yourself with both feet to leap laterally over the cone, focusing on elevation and distance. Gently land on the balls of your feet on the other side, maintaining a slight bend in your knees. Quickly reset and return to the initial position.

*Burpees:*

- a. Target fitness components: Full-body

strength and explosive power.

b. Benefits: Integrates aerobic and anaerobic components, enhancing overall conditioning and power production. Excellent for improving endurance in extended matches.

c. Execution: Begin in a standing position with your feet shoulder-width apart. Assume a squat position, placing your hands flat on the ground in front of you. Propel your feet backward into a plank position, ensuring your body maintains a straight alignment from head to heels. Quickly bring your feet back toward your hands. Execute an explosive vertical jump, extending your arms overhead. Descend gently and promptly proceed to the subsequent repetition.

*Squat Jump:*

- a. Target fitness components: Explosive power, strength, and vertical jump ability.
- b. Benefits: Strengthens the quadriceps, hamstrings, and glutes while increasing vertical leap, which is essential for blocking and spiking.
- c. Execution: Stand with your feet shoulder-width apart. Lower into a squat position, keeping your chest upright and knees behind your toes. Explode upward, jumping as high as possible. Land softly, immediately lowering into the next squat to repeat.

*Box Jump:*

- a. Target fitness components: Explosive power, coordination, and strength.
- b. Benefits: Boosts vertical jump, reflexes, and muscle coordination. Practicing safe landings builds confidence for game situations.
- c. Execution: Position yourself in front of a solid box or platform. Stand with your feet shoulder-width apart, bend your knees, and swing your arms back to generate momentum. Explode upward and propel yourself forward, landing gently on the box with both feet. Assume an upright position, then descend carefully, stepping down one foot at a time. Repeat for the specified number of repetitions.

*Sprint (40-meter dash):*

- a. Target fitness components: Speed, acceleration, and endurance.
- b. Benefits: Develops quick bursts of speed necessary for reaching the ball and covering

the court. Improves overall reaction time and cardiovascular fitness.

c. Execution: Start by standing with your weight on the balls of your feet and your back straight. As you move forward, take long strides and pump your arms simultaneously. Maintain a slight forward lean and engage your core to stay balanced. Run as fast as you can for the given distance. Slow down gradually to avoid sudden stops.

*Training program.* Participants were randomly allocated into two groups: the experimental group (n = 20) and the control group (n = 20). The training intervention lasted four weeks, comprising three sessions per week for the volleyball players. The experimental group engaged in a plyometric workout program, whereas the control group maintained their standard training schedule. Pre-training and post-training assessments were administered before and after the execution of the training program. Before the test protocols, participants engaged in a familiarization session to prevent any issues during testing. All tests were performed in a covered court under appropriate conditions, at least 24 hours after the previous training session or match. Participants were instructed to wear similar athletic apparel during the testing periods. Measurements were conducted concurrently at the same time of day over three testing sessions to mitigate the impact of daily variations on the chosen parameters. Participants received recommendations regarding nutrition and rest during the training and testing phases to minimize any potential factors that could influence the study outcomes. Table 2 provides information about the applied training program.

#### *Statistical Analysis*

The data were analyzed using SPSS version 20. Descriptive statistics, including the mean, frequency, and standard deviation, were used to analyze quantitative data. The normality of the data was evaluated using the Shapiro-Wilk test.

It was observed that the data exhibited a normal distribution. Within-group pre- and post-test scores were analyzed using a paired samples t-test, and inter-group differences were evaluated using an independent samples t-test. The significance level was established at  $p < 0.05$ . Upon reviewing the table, it is evident that the experimental and control groups exhibit comparable descriptive statistics.

## Results

The pre-test results displayed in Table 3 reveal no statistically significant differences between the experimental and control groups across all evaluated plyometric exercises, including lateral cone hops, burpees, squat jumps, box jumps, and sprints ( $p > 0.05$ ). The absence of notable differences indicates that the two groups were equivalent in their baseline plyometric performance prior to the intervention. Such comparability is essential in experimental research, as it guarantees that any detected post-test differences can be attributed to the intervention rather than pre-existing discrepancies. This finding corroborates the randomized group allocation and reinforces the reliability of subsequent analyses.

The results of the independent samples t-test for these comparisons are presented in Table 4. The results illustrate notable improvements in the post-test plyometric exercise scores of the experimental group relative to the control group across all five plyometric exercises. The experimental group attained markedly superior scores in lateral cone hops ( $t = 14.399$ ,  $p < 0.001$ ) and squat jumps ( $t = 17.199$ ,  $p < 0.001$ ) compared to the control group. The results indicate the efficacy of the 4-week plyometric training program in improving specific fitness components essential for volleyball performance. The findings suggest that systematic plyometric workouts can improve physical competency, providing evidence-based advice for physical education and sports training.

The findings demonstrate that both the

**Table 2.** Plyometric training program

Week	Plyometric Exercise Program	Sets	Reps	Rest	Duration
1-2	Lateral Cone Hops	2	8	180 seconds	30-40 minutes
	Burpees				
	Squat Jump				
	Box Jump				
	Sprint				
3-4	Lateral Cone Hops	3	12	180 seconds	30-40 minutes
	Burpees				
	Squat Jump				
	Box Jump				
	Sprint				

**Table 3.** Pre-test scores for both experimental and control groups

Movement Patterns	Group	N	M	SD	t-value	p-value
Lateral Cone Hops	Experimental	20	5.400	0.821	-1.815	0.077
	Control	20	5.850	0.745		
Burpees	Experimental	20	5.300	1.031	0.128	0.899
	Control	20	5.250	1.410		
Squat Jump	Experimental	20	4.700	0.657	-1.013	0.318
	Control	20	4.950	0.887		
Box Jump	Experimental	20	4.850	0.671	-1.217	0.231
	Control	20	5.150	0.875		
Sprint	Experimental	20	5.050	0.759	0.841	0.406
	Control	20	4.850	0.745		

**Table 4.** Post-test scores for both experimental and control groups

Movement Patterns	Groups	N	M	SD	t-value	p-value
Lateral Cone Hops	Experimental	20	9.450	0.686	14.399	< .001
	Control	20	6.500	0.607		
Burpees	Experimental	20	13.050	1.572	3.260	0.002
	Control	20	11.700	0.979		
Squat Jump	Experimental	20	9.550	0.510	17.199	< .001
	Control	20	6.500	0.607		
Box Jump	Experimental	20	9.050	0.686	12.034	< .001
	Control	20	6.600	0.598		
Sprint	Experimental	20	8.250	1.209	2.904	0.006
	Control	20	7.400	0.503		

experimental and control groups exhibited substantial improvements in their physical fitness performance from pre-test to post-test (Table 5). The experimental group, which participated in an adapted plyometric training program, showed significantly greater improvements in all measured plyometric exercises, including lateral cone hops ( $M = 4.050, p < 0.001$ ), burpees ( $M = 7.750, p < 0.001$ ), squat jumps ( $M = 4.850, p < 0.001$ ), box jumps ( $M = 4.200, p < 0.001$ ), and sprints ( $M = 3.200, p < 0.001$ ). The mean differences in performance gains were consistently greater in the experimental group compared to the control group, underscoring the efficacy of plyometric training in enhancing the physical fitness of novice volleyball players. This highlights the necessity of incorporating specialized training programs to enhance athletic performance, especially among young volleyball players.

**Discussion**

The aim of the study was to evaluate the effects of a 4-week plyometric training program on specific physical fitness components in under-21 novice

volleyball players. The findings demonstrated significant improvements in performance across specific fitness components (i.e., power, strength, agility, coordination, balance, and speed), with statistically significant differences ( $p < 0.01$ ) observed between pre-test and post-test results. The experimental group showed a notable increase in all measured components, reinforcing the effectiveness of plyometric training in enhancing volleyball-specific fitness. This study emphasizes the efficacy of a short training program designed for novice volleyball players, in contrast to prior research that focused on elite athletes or extended training periods (e.g., six to eight weeks) [3, 14]. Our findings suggest that even a 4-week program can yield measurable improvements, filling a gap in research on beginner-level training interventions. This study included a variety of plyometric exercises (e.g., lateral cone hops, burpees, squat jumps, box jumps, and sprints), each aimed at developing specific physical attributes. Although previous research frequently highlights improvements in vertical jump [30, 38], the results of this study illustrate

**Table 5.** Paired sample t-test of scores in the experimental and control groups of volleyball players

Variable	Group	Pre-Test	Post-Test	Mean Difference	t-value	p-value
		M ± SD	M ± SD	M		
Lateral Cone Hops	Experimental	5.400 ± .821	9.450 ± .686	4.050	19.176	< .001
	Control	5.850 ± .745	6.500 ± .607	.650	2.942	.008
Burpees	Experimental	5.30 ± 1.031	13.050 ± 1.572	7.750	-17.358	< .001
	Control	5.250 ± 1.410	11.700 ± .979	6.450	16.962	< .001
Squat Jump	Experimental	4.700 ± v.657	9.550 ± .510	4.850	29.108	< .001
	Control	4.950 ± .887	6.500 ± .607	1.550	7.339	< .001
Box Jump	Experimental	4.850 ± .671	9.050 ± .686	4.200	10.514	< .001
	Control	5.150 ± .875	6.600 ± .598	1.450	5.900	< .001
Sprint	Experimental	5.050 ± .759	8.250 ± 1.209	3.200	18.685	< .001
	Control	4.850 ± .745	7.400 ± .503	2.550	16.616	< .001

that plyometric training can enhance several fitness elements essential for volleyball performance.

Our findings align with research confirming the benefits of plyometric training for power and jump performance [11, 40, 41]. The improvements in squat jumps and box jumps support the idea that plyometric exercises enhance lower-body explosiveness, which is crucial for spiking and blocking [26]. Additionally, the significant gains in agility and speed observed in this study are consistent with previous research indicating that structured plyometric training enhances reaction time and movement efficiency [7, 11, 42]. Although research has examined plyometric training in soccer and basketball [5, 7], volleyball requires distinct movement patterns, including lateral agility and explosive jumps. The study findings indicate that the selected exercises effectively target these volleyball-specific demands, making this study particularly relevant to the sport. The study's findings corroborate previous research, demonstrating that the plyometric training program significantly enhanced jumping performance in the experimental group compared to the control group. Plyometric exercises, whether performed with or without external weights, have been widely recognized for their effectiveness in improving explosive power, strength, and sprint performance [42, 43, 44]. Notably, the inclusion of burpees in the training regimen contributed to overall strength and physical endurance, enabling athletes to sustain peak performance for prolonged periods [28, 45, 46]. Given their high-intensity nature and the engagement of multiple muscle groups simultaneously, burpees facilitate improvements in muscular strength, endurance, and cardiovascular fitness. Consequently, players develop greater stamina and the ability to maintain optimal performance levels during high-intensity gameplay.

Furthermore, the results revealed significant

improvements in key physical fitness components, such as speed and coordination, among novice volleyball players. Speed and coordination exercises contributed to enhanced reaction times and improved movement efficiency on the court, thereby elevating both offensive and defensive performance [2, 33, 47]. The integration of these exercises into a volleyball training program not only enhances individual performance but also strengthens overall team dynamics. Players develop a heightened ability to anticipate opponents' movements, execute precise actions, and transition seamlessly between plays, contributing to a more cohesive and effective team strategy. These enhancements align with prior studies indicating that plyometric training improves neuromuscular efficiency and muscle activation patterns [27, 41]. By fostering better motor control and explosive power, such training directly benefits volleyball-specific movements, such as jumping, quick lateral shifts, and sudden accelerations [4, 26].

The structured nature of the training program, which incorporated progressive increments in sets and repetitions, allowed athletes to adapt gradually and safely, reinforcing the importance of systematic load progression in athletic training. This progressive approach not only optimized performance gains but also minimized the risk of injury. Collectively, the improvements observed in agility, power, strength, coordination, and speed highlight the comprehensive benefits of plyometric training for volleyball players. Enhanced physical capabilities translate into more efficient execution of volleyball-specific skills, leading to superior individual performance, improved team cohesion, and an increased likelihood of success in competitive settings. Additionally, these physical gains contribute to injury prevention, prolong athletic careers, and establish a solid foundation for future training advancements. Thus, the study

underscores the efficacy of plyometric training in developing the critical physical attributes necessary for volleyball performance. By systematically integrating plyometric exercises into training programs, coaches and athletes can achieve significant improvements in athleticism, facilitating higher levels of performance while ensuring long-term physical development.

Notwithstanding the substantial findings, this study presents several limitations that warrant consideration. The short duration of the intervention, restricted to four weeks, may not adequately reflect the long-term impacts of plyometric exercise on physical fitness components. The sample size was limited and confined to novice volleyball players aged 19–21, thus constraining the generalizability of the findings to other age demographics, skill levels, and sports disciplines. Furthermore, the study failed to account for individual differences in fitness levels, training history, or program adherence, which could have impacted the outcomes. Ultimately, the study depended exclusively on performance-based metrics, omitting biomechanical or physiological evaluations that would have offered more profound insights into the mechanisms underlying the reported enhancements. Future research ought to prioritize extended studies with larger and more diverse groups to enhance comprehension of the long-term impacts of plyometric exercise. Moreover, investigating the effects of diverse plyometric training protocols, encompassing differences in intensity, frequency, and exercise selection, may yield more tailored recommendations for athletes. Integrating biomechanical and physiological evaluations could enhance the comprehension of plyometric training's impact on performance and its role in mitigating injury risk.

## Conclusions

The results of this study indicate that a 4-week plyometric training program markedly improves essential physical fitness attributes, such as agility, speed, power, strength, coordination, and balance, in novice volleyball players aged 19 to 21. The experimental group demonstrated significant enhancements in performance metrics, including lateral cone hops, squat jumps, box jumps, and sprints, relative to the control group, underscoring the effectiveness of specific plyometric activities. These findings highlight the need to integrate plyometric training into volleyball training programs to enhance athletic performance and equip players for the sport's dynamic requirements. This study establishes a basis for subsequent research by highlighting the significance of organized plyometric exercise in cultivating fundamental fitness characteristics. It also emphasizes topics for further exploration, including the long-term effects of plyometric exercise, its applicability across diverse age groups and skill levels, and the influence of varying training intensities and durations. Additionally, this study serves as a practical reference for developing evidence-based training routines to improve athletic performance and mitigate injury risk in volleyball and other sports.

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## Conflict of interests

The authors declare that there is no conflict of interests.

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### Information about the authors:

**Jet Longakit**; (Corresponding author); <https://orcid.org/0000-0002-6193-7492>; [jet.longakit@g.msuiit.edu.ph](mailto:jet.longakit@g.msuiit.edu.ph); College of Education, Department of Physical Education, MSU-Iligan Institute of Technology; Iligan City, Philippines.

**Felix Jr. Aque**; <https://orcid.org/0009-0005-0366-7016>; [felixjr.aque@g.msuiit.edu.ph](mailto:felixjr.aque@g.msuiit.edu.ph); College of Education, Department of Physical Education, MSU-Iligan Institute of Technology; Iligan City, Philippines.

**Lyndie Toring-Aque**; <https://orcid.org/0009-0009-6013-1305>; [lyndie.toring@g.msuiit.edu.ph](mailto:lyndie.toring@g.msuiit.edu.ph); College of Education, Department of Physical Education, MSU-Iligan Institute of Technology; Iligan City, Philippines.

**Joseph Lobo**; <https://orcid.org/0000-0002-2553-467X>; [joseph.lobo@bulsu.edu.ph](mailto:joseph.lobo@bulsu.edu.ph); College of Sports, Exercise and Recreation, Bulacan State University; Bulacan, Philippines.

**Novadri Ayubi**; <https://orcid.org/0000-0002-5196-6636>; [novadriayubi@unesa.ac.id](mailto:novadriayubi@unesa.ac.id); Universitas Negeri Surabaya; Surabaya, Indonesia.

**Ranel Mamon**; <https://orcid.org/0009-0002-6414-2350>; [nelmamon@cmc.edu.ph](mailto:nelmamon@cmc.edu.ph); College of Teacher Education, Central Mindanao Colleges; Kidapawan, Philippines.

**Lloyd Coming**; <https://orcid.org/0009-0006-2237-1816>; [lloydiecoming@gmail.com](mailto:lloydiecoming@gmail.com); Department of Teacher Education, Kolehiyo ng Pantukan; Davao de Oro, Philippines.

**Desiree Kate Padilla**; <https://orcid.org/0009-0000-9170-3243>; [desireekatedano@buku.edu.ph](mailto:desireekatedano@buku.edu.ph); Bukidnon State University; Bukidnon, Philippines.

**Christian Alex Mondido**; <https://orcid.org/0009-0009-8040-6548>; [camondido@rtu.edu.ph](mailto:camondido@rtu.edu.ph); Institute of Human Kinetics, Rizal Technological University; Mandaluyong, Philippines.

**Jay Mark Sinag**; <https://orcid.org/0000-0002-2042-0155>; [jmdpsinag@bpsu.edu.ph](mailto:jmdpsinag@bpsu.edu.ph); Bataan Peninsula State University; Philippines.

**Vlad Adrian Geanta**; <https://orcid.org/0000-0002-8488-1698>; [vlad.geanta@uav.ro](mailto:vlad.geanta@uav.ro); Faculty of Physical Education and Sport, Aurel Vlaicu University of Arad; Romania.

**Swamynathan Sanjaykumar**; <https://orcid.org/0000-0001-9945-2223>; [sanjayswaminathan007@gmail.com](mailto:sanjayswaminathan007@gmail.com); Department of Physical Education and Sports, Sree Sankaracharya University of Sanskrit, Kalady, Kerala, India.

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