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Original article

Arm utilization index and vertical jump performance in adolescent volleyball players from Peru: comparative analysis by category

[*Índice de utilización de brazos y rendimiento de salto vertical en voleibolistas adolescentes de Perú: análisis comparativo por categoría*]

[*Índice de utilização dos braços e desempenho no salto vertical em voleibolistas adolescentes do Peru: análise comparativa por categoria*]

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ABSTRACT

Introduction: Vertical jump in volleyball is a key factor for success in this sport, but there is also an influence from the contribution of the arms.
Objective: to analyze the arm utilization index (IUB) and vertical jump performance in adolescent volleyball players from Lima, Peru, in two training categories (pre-infant and infant).

Methods: A descriptive, quantitative study was conducted with a sample of 17 female players aged 11 to 15 years, who were evaluated using countermovement jump (CMJ) and free-arm countermovement jump (ABK) tests with a Vald ForceDecks force platform. The IUB was calculated as the percentage difference between jump height in the CMJ and ABK tests.

Results: The junior volleyball players showed higher values for CMJ (26.80 ± 7.03 cm) and ABK (33.33 ± 9.91 cm) compared to the pre-junior players (CMJ: 24.19 ± 5.54 cm; ABK: 30.21 ± 7.84 cm). However, the IUB was similar between groups (pre-junior: 24.89 ± 16.42%; junior: 23.83 ± 13.77%). The effect size calculated using Cohen's d indicated a moderate difference in CMJ (d = 0.41) and a small difference in ABK (d = 0.35) between categories. In contrast, the IUB showed a very small effect size (d = 0.07).

Conclusion: These findings indicate that, although children's volleyball players have higher performance in jumping, the contribution of the arms to the jumping gesture does not vary relatively between training categories, which could reflect an early stabilization of this specific motor skill.

Keywords: vertical jump, volleyball, adolescents, athletic performance.

RESUMEN

Introducción: el salto vertical en voleibol es un factor clave para el éxito en este deporte, pero existe influencia de la contribución de los brazos.

Objetivo: analizar el índice de utilización de brazos (IUB) y el rendimiento del salto vertical en voleibolistas adolescentes de Lima, Perú, en dos categorías de formación (preinfantil e infantil).

Métodos: para ello, se realizó un estudio con enfoque cuantitativo de tipo descriptivo, con una muestra de 17 jugadoras entre 11 a 15 años, que fueron evaluadas mediante pruebas de salto con contramovimiento (CMJ) y salto con contramovimiento con brazos libres o Abalakov (ABK) utilizando una plataforma de fuerza Vald ForceDecks. El IUB se calculó como la diferencia porcentual entre la altura de salto en CMJ y en ABK.

Resultados: las voleibolistas infantiles presentaron mayores valores en CMJ (26.80 ± 7.03

cm) y ABK (33.33 ± 9.91 cm) en comparación con las preinfantiles (CMJ: 24.19 ± 5.54 cm; ABK: 30.21 ± 7.84 cm). Sin embargo, el IUB fue similar entre grupos (preinfantil: 24.89 ± 16.42%; infantil: 23.83 ± 13.77%). El tamaño del efecto calculado mediante Cohen (d) indicó una diferencia moderada en CMJ (d = 0.41) y una diferencia pequeña en ABK (d = 0.35) entre categorías. En contraste, el IUB presentó un tamaño de efecto muy pequeño (d = 0.07).

Conclusión: Estos hallazgos indican que, aunque las voleibolistas infantiles tienen mayor rendimiento en el salto, la contribución de los brazos al gesto de salto no varía relativamente entre categorías formativas, lo que podría reflejar una estabilización temprana de esta habilidad motora específica.

Palabras clave: salto vertical, voleibol, adolescentes, rendimiento atlético.

RESUMO

Introdução: o salto vertical no voleibol é um fator-chave para o sucesso neste esporte, havendo, contudo, a influência da contribuição dos braços.

Objetivo: analisar o índice de utilização dos braços (IUB) e o desempenho no salto vertical em jogadoras de voleibol adolescentes de Lima, Peru, em duas categorias de formação (pré-infantil e infantil).

Métodos: para isso, realizou-se um estudo de abordagem quantitativa e caráter descritivo, com uma amostra de 17 jogadoras com idades entre 11 e 15 anos. Elas foram avaliadas por meio de testes de salto com contramovimento (CMJ) e salto com contramovimento com uso dos braços (ABK — *Abalakov*), utilizando uma plataforma de força *Vald ForceDecks*. O IUB foi calculado como a diferença percentual entre a altura do salto no CMJ e no ABK. Resultados: as jogadoras da categoria infantil apresentaram valores maiores tanto no CMJ (26,80 ± 7,03 cm) quanto no ABK (33,33 ± 9,91 cm) em comparação com as da categoria pré-infantil (CMJ: 24,19 ± 5,54 cm; ABK: 30,21 ± 7,84 cm). No entanto, o IUB foi semelhante entre os grupos (pré-infantil: 24,89 ± 16,42%; infantil: 23,83 ± 13,77%). O tamanho do efeito, calculado pelo índice *d* de Cohen, indicou uma diferença moderada no CMJ (*d* = 0,41) e uma diferença pequena

no ABK (*d* = 0,35) entre as categorias. Em contrapartida, o IUB apresentou um tamanho de efeito muito pequeno (*d* = 0,07).

Conclusão: Estes achados indicam que, embora as jogadoras de voleibol infantis apresentem maior desempenho no salto, a contribuição dos braços para o gesto do salto não varia, em termos relativos, entre as categorias de formação, o que poderia refletir uma estabilização precoce dessa habilidade motora específica.

Palavras-chave: salto vertical, voleibol, adolescentes, desempenho atlético.

INTRODUCTION

Vertical jumping is a crucial ability in volleyball performance, especially in youth categories where motor development and coordination are still maturing. The use of the arms during the jump is a key biomechanical factor that can increase takeoff power and optimize energy transfer (Yamashita *et al.*, 2025).

Despite the importance of this variable, in the Peruvian context there is no systematic research analyzing arm use in adolescents, nor the widespread use of jump or strength platforms in adolescent populations. This limited scientific literature restricts the understanding of coordinative development and the planning of training during formative stages.

This research aims to establish a benchmark for the arm utilization index (AUI) in adolescent volleyball players in Lima, using advanced technologies such as the Vald platform, to guide coaches on the importance of coordination in early athletic development. Therefore, the overall objective is to analyze the AUI and vertical jump performance in young volleyball players from Lima, classified into pre-infant and infant categories.

The findings confirm that coordinated arm use directly influences vertical jump performance. Recent studies (Vaverka et al., 2016; Deng et al., 2025) support the idea that

arm contribution enhances angular momentum and optimizes the final extension of the jump.

The limited exposure to technologies such as force or jump platforms in youth categories in Peru restricts the development of a scientific basis for sports training. Implementing objective assessment tools can improve talent identification and motor training planning (Salim *et al.,* 2024).

In accordance with the above, the present research aims to create an index of arm utilization and vertical jump performance in adolescent volleyball players from Peru.

MATERIALS AND METHODS

Studio design

The present study had a quantitative design of a descriptive and comparative type, aimed at analyzing the differences in the arm utilization index (IUB) and vertical jump performance between formative categories of volleyball (pre-infant and infant).

Participants

The sample consisted of 17 female adolescent volleyball players, belonging to the Cultura Voleibol Club (CVC) of Lima-Barranco (Peru), aged between 11 and 15 years. The participants were classified into two training categories (pre-infant, n = 9, and infant, n = 8) and Table 1 shows the general characteristics with the mean and standard deviation of age, height and body weight.

Table 1. *General characteristics of the volleyball players (mean ± SD)*

Category	Age (years)	Height (m)	Weight (kg)
Pre-infant (9)	12.43 ± 0.81	1.57 ± 0.07	50.23 ± 5.50
Children's (8)	14.69 ± 1.19	1.59 ± 0.07	54.00 ± 6.75

The inclusion criteria for participation in the study included: 1) regular attendance at CVC volleyball training sessions and 2) abstaining from psychoactive substances or alcohol the day before the jump tests. Exclusion criteria included: 1) any lower limb injury that would prevent the performance of CMJ and ABK jumps.

Furthermore, this research was conducted in accordance with the ethical standards of the Declaration of Helsinki, and informed consent was obtained from the legal representatives of the participating players.

Tools

For vertical jump measurement, a VALD ForceDecks force platform (model FD4000) was used, which provides precise measurements of flight time, takeoff force, and height reached, with a sampling frequency of 1000 Hz, previously calibrated. The tests performed on the force platform were the CMJ (countermovement jump) and ABK (arm swing jump), where each participant made three attempts per test, and the best jump height (cm) was recorded for statistical analysis.

Procedures

The assessments were conducted at the CVC facilities over two days of the same week to minimize the influence of fatigue. On Tuesday, the CMJ familiarization and assessment took place, and on Thursday, the ABK familiarization and assessment were performed. Before each session, the athletes completed a standardized warm-up protocol designed by the G Performance Lab technical staff, consisting of: 5 minutes of general joint mobility exercises, 5 minutes of dynamic activation exercises, and 3 submaximal familiarization jumps. Subsequently, the CMJ and ABK jump tests were administered, with 45-second rest periods between jumps. Each participant performed three valid attempts per test, and the best result was selected for statistical analysis. The data obtained were exported directly from VALD Hub v2.6 software to spreadsheets for statistical processing in Microsoft Excel.

Furthermore, the arm utilization index (IUB) was calculated using the formula:

$$IUB=\frac{\text{Altura CMJ-Altura ABK}}{\text{Altura CMJ}}*100$$

Statistical analysis

A descriptive and comparative statistical analysis was performed to evaluate vertical jump performance and arm utilization index (AUI) in adolescent volleyball players from Lima, Peru, differentiated by training category (pre-infant and infant). First, measures of central tendency and dispersion (mean and standard deviation) were calculated for the variables age, height, weight, CMJ, ABK, and AUI.

Subsequently, the effect size of *d* between categories was calculated using Cohen's statistic (1998) to determine the magnitude of the differences in the CMJ, ABK, and IUB variables. Cohen's (1998) *d values* were interpreted according to conventional criteria: small ($d \approx 0.2$), moderate ($d \approx 0.5$), and large ($d \geq 0.8$).

RESULTS AND DISCUSSION

Table 2 shows the mean and standard deviation for CMJ and ABK, as well as IUB. Furthermore, analysis of the effect size reveals a moderate difference in CMJ ($d = 0.41$) and a small difference in ABK ($d = 0.35$), while IUB showed a very small effect ($d = 0.07$). These findings suggest that, although physical performance improves with age and development, technical efficiency in arm use during jumping appears to be consolidated early in the training process (Table 2).

Table 2. *Vertical jump height in CMJ and ABK and IUB of adolescent volleyball players*

Category	CMJ	ABK	IUB
Pre-infant (9)	24.19 ± 5.54	30.21 ± 7.84	24.89 ± 16.42
Children's (8)	26.80 ± 7.03	33.33 ± 9.91	23.83 ± 13.77
TE (d)	0.41	0.35	0.07

**TE: Effect size.*

Upon further investigation, authors such as Hernández and Cisterna (2022) were found, who systematically analyzed the physical performance of adolescent volleyball players from a school in Italy, focusing on the importance of arm and hip strength in the player's takeoff. While the relevance and novelty of this research are acknowledged, the main difference from the present study lies in the application of CMJ and ABK jumps, as well as the association of IUB (Index of Bumps), aspects that allow for greater precision in planning and periodization for coaches.

Furthermore, it is worth highlighting the work of Avilés (2025), who focused on analyzing the comprehensive physical development of adolescents to provide them with long-term benefits, as well as improving their athletic performance to meet the current physical demands of sports. To evaluate jumping ability, these authors used the technique and methodological guidelines of the Sargent vertical jump test. The main limitation of this research is the bias caused by performing the jump against a wall, which limits the accuracy of the volleyball players' power output during this test. Therefore, in our research, we used the VALD ForceDecks force platform (model FD4000), which provides a more precise quantification of the athlete's jump performance.

Another study to consider is that of Punin and Paredes (2025), who argue that volleyball demands specific motor skills, such as coordination and balance, which are fundamental for efficient performance. One limitation of this research is its lack of connection to lower body power. Since the main athletic movement in volleyball is the jump, power plays a crucial role. Therefore, we evaluated jumps such as the Abalakov jump and the

countermovement jump (CMJ), and associated them with the incoming jump (IUB), aspects that are more closely related to the athletic skills required by these athletes.

On the other hand, Cáceres (2025) identified a correlation between anthropometric variables and gender with the vertical jump of athletes on the University of Santander (UDES) volleyball team. This study involved the intentional modification of biological, physiological, psychological, and social variables of the participants. Although this research addressed some physiological variables, the morphophysiological characterization of volleyball was insufficient, highlighting the poor identification of jumping power as a fundamental variable to consider. Therefore, the present research focused on analyzing the arm utilization index and vertical jump performance in adolescent volleyball players from Peru.

CONCLUSIONS

The results of this study show that adolescent volleyball players in the children's category exhibit superior performance in the vertical jump (CMJ and ABK) compared to their pre-children's peers. However, the arm utilization index (IUB), which reflects the technical contribution of arm movement to the jump, showed no differences between categories, which could reflect an early stabilization of this specific motor skill.

Taken together, these results highlight the importance of evaluating not only jump performance but also the quality of the technical movement. The IUB (Index of Jumping) is presented as a useful parameter for monitoring intersegmental coordination in formative stages, allowing coaches and physical trainers to focus jump instruction beyond explosive power, prioritizing technical integration from an early age.

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***Conflict of interest*:**

The authors declare no conflicts of interest.

***Authors' contribution*:**

The authors have participated in the writing of the work and analysis of the documents.

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