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***Original article***

# *The isometric exercise elbow plank and body composition in adolescent handball players*

[*El ejercicio isométrico elbow plank y la composición corporal en jugadores adolescentes de balonmano*]

[*O exercício isométrico elbow plank e a composição corporal em jogadores adolescentes de handebol*]

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*ABSTRACT*

**Introduction:** In handball, throwing, blocking, and movement require postural control; the core muscles stabilize the trunk and facilitate technical movements.

**Objective:** To analyze the relationship between body composition (BMI, body fat percentage, fat-free mass) and performance in the elbow isometric test. plank in adolescents.

**Materials and methods:** 30 handball players aged 13-14 years participated. Body composition, body mass index, body fat percentage, and fat-free mass were measured, in addition to elbow endurance time. Planck. Descriptive and inferential statistics were applied using R 4.4.1 software.

**Results:** In males, a significant inverse relationship was found between elbow time Plank and two indicators of adiposity: BMI ($r^2$ = 29.3%) and body fat percentage ($r^2$ = 27.9%). Higher body fat was associated with lower endurance. Fat-free mass was not significantly correlated. In women, no significant correlations were found, although there was a slight trend: more fat was associated with lower time and more muscle with higher endurance. However, the confidence intervals crossed zero, so no statistically significant conclusions can be drawn.

**Conclusions:** Excess body fat negatively affects core stability in men. In women, the relationship was ambiguous. These findings reinforce the importance of promoting a healthy body composition to optimize functional performance, prevent injuries, and adjust training according to pubertal development.

**Keywords:** body composition, elbow plank, arm plank, core stability.

*RESUMEN*

**Introducción**: en el balonmano, los lanzamientos, bloqueos y desplazamientos requieren control postural, la musculatura del core estabiliza el tronco y facilita movimientos técnicos. **Objetivo**: analizar la relación entre composición corporal (IMC, % de grasa, masa libre de grasa) y el rendimiento en la prueba isométrica elbow plank en adolescentes.

**Materiales y métodos**: participaron 30 jugadores de balonmano de 13-14 años. Se midieron la composición corporal, índice de masa corporal, el porcentaje de grasa corporal y la masa libre de grasa, además del tiempo de resistencia del elbow plank. Se aplicó estadística descriptiva e inferencial con software R 4.4.1.

**Resultados:** en varones, se halló una relación inversa y significativa entre el tiempo de elbow plank y dos indicadores de adiposidad: IMC ($r^2$ = 29.3%) y % de grasa corporal ($r^2$ = 27.9%). A

mayor grasa, menor resistencia. La masa libre de grasa no tuvo correlación significativa. En las mujeres, no se encontraron correlaciones significativas, aunque hubo una leve tendencia: más grasa se relacionó con menor tiempo y más músculo con mayor resistencia. Sin embargo, los intervalos de confianza cruzaron cero, por lo que no se puede afirmar estadísticamente.

**Conclusiones**: el exceso de grasa corporal condiciona negativamente la estabilidad central en varones. En las mujeres, la relación fue ambigua. Estos hallazgos refuerzan la importancia de promover una composición corporal saludable para optimizar el rendimiento funcional, prevenir lesiones y ajustar los entrenamientos según el desarrollo puberal.

**Palabras clave**: composición corporal, Elbow plank, plancha de brazo, estabilidad core.

*RESUMO*

**Introdução**: No handebol, os arremessos, bloqueios e deslocamentos exigem controle postural; a musculatura do core estabiliza o tronco e facilita os movimentos técnicos.

**Objetivo**: Analisar a relação entre a composição corporal (IMC, percentual de gordura e massa magra) e o desempenho no teste isométrico de prancha de cotovelo em adolescentes.

**Materiais e métodos**: Participaram 30 jogadores de handebol com idades entre 13 e 14 anos. Foram avaliados a composição corporal, o índice de massa corporal, o percentual de gordura e a massa magra, além do tempo de resistência na prancha de cotovelo. Aplicaram-se estatísticas descritivas e inferenciais com o software R (versão 4.4.1).

**Resultados**: Nos meninos, encontrou-se uma relação inversa e significativa entre o tempo da prancha de cotovelo e dois indicadores de adiposidade: IMC ($r^2$ = 29,3%) e percentual de gordura corporal ($r^2$ = 27,9%). Quanto maior a gordura, menor a resistência. A massa magra não apresentou correlação significativa. Nas meninas, não foram encontradas correlações significativas, embora uma leve tendência tenha sido observada: mais gordura se associou a menor tempo, e mais músculo a maior resistência. No entanto, os intervalos de confiança cruzaram zero, impedindo uma afirmação estatística.

**Conclusões**: O excesso de gordura corporal afeta negativamente a estabilidade do core nos meninos. Nas meninas, a relação foi ambígua. Esses achados reforçam a importância de promover uma composição corporal saudável para otimizar o desempenho funcional, prevenir lesões e ajustar os treinos de acordo com o desenvolvimento puberal.

**Palavras-chave**: Composição corporal, Prancha de cotovelo, Prancha isométrica, Estabilidade do core

## *INTRODUCTION*

In handball, trunk stabilization and force transmission to the upper and lower extremities rely on strong core muscles. This biomechanical function influences the technical execution of throws and blocks, promoting greater coordination and postural control (Varela *et al.,* 2020; García *et al.,* 2023; Ferragut *et al., 2021). The* elbow test has proven reliable for assessing core strength, even in children. plank (Boyer *et al.,* 2013; Ballen, 2021). Furthermore, it has been integrated into injury prevention and motor performance improvement programs by activating essential muscles such as the trapezius, obliques, and rectus abdominis (Villaquiran, 2020; Vila *et al.,* 2022; Ali *et al.,* 2022; Can *et al.,* 2024; Choi *et al.,* 2025; Gal *et al.,* 2023); Hannon, (2020). Its application is used as an indicator of muscle status.

The relationship between body composition and physical performance is a topic of current interest (Letelier *et al.,* 2024; Ramos *et al.,* 2024). Likewise, body mass index (BMI) is a widely used tool for assessing nutritional status and potential health risks (a higher-than-normal BMI could be an indicator of excess body fat) (López *et al.,* 2020). However, several studies suggest limitations in using BMI as an individual indicator of body fat, due to its limited sensitivity in distinguishing between lean mass and fat, as well as its variability according to sex, age, and ethnicity (Martínez *et al.,* 2018; Carrasco *et al.,* 2021; Flores, 2021; Román *et al.,* 2022). Therefore, supplementing the information with data such as fat-free mass (FFM) and body fat percentage (BF) allows for a better understanding of physical capacity in athletes (Carrero *et al.,* 2020; World Health Organization [WHO], 2020; Román *et al.,* 2022)

In technical-tactical performance, handball demands a prevalence of explosive movements, in addition to intermittent efforts. The core plays a key role in injury prevention (Henrique *et al.,* 2024; Javier *et al.,* 2021; Vila *et al.,* 2022; Montes *et al.,* 2025). The repetitive execution of movements such as throws and blocks has been associated with functional overloads, especially in the shoulder joint, which underscores the importance of training and evaluating core musculature to maintain the physical integrity of players (Tooth. *et al.,* 2020; Scheverin, 2020). Furthermore, recent research shows an increase in isometric strength, greater trunk muscle activation, and

improved functional mobility when applying exercises such as the elbow raise. plank in training programs (Laguarta *et al.,* 2024; Fallahasady *et al.,* 2022; Panidi *et al.,* 2023).

This study aims to analyze the relationship between body composition (body mass index, body fat percentage, and fat-free mass) and isometric elbow exercise. plank in handball players aged 13 to 14.

Finally, the exploratory question is: What is the relationship between these body variables and performance on a core stability test like the elbow test Plank? With the aim of understanding how body composition influences the core stability of adolescents (at this stage of pubertal development external and internal physical changes occur that can directly affect training), to optimize training and functional assessment in young athletes.

## *MATERIALS AND METHODS*

A descriptive, cross-sectional and correlational study was conducted, using empirical, mathematical and statistical methods, with the participation of athletes from the Partille Club Peru, located in the district of La Molina, Lima.

Participants were selected using non-probability sampling based on convenience and defined criteria. This resulted in a group of 30 athletes: 15 women (50%) and 15 men (50%), aged 13 to 14, who train on average three times a week, for approximately two hours per session. Participants were athletes who reported no limitations, physical problems, or injuries. Subjects who had experienced a sports injury in recent weeks and those who did not complete the test were excluded.

Data collection took place in a closed environment at the facilities of the Carlos Lisson Beingolea School, the club's headquarters, which is endorsed by the Peruvian Handball Federation. The tests were conducted over two days, from 9:00 a.m. to 12:00 p.m.

Weight was obtained using a calibrated Tanita Innerscan Pro RD -545HR electronic scale with a margin of error of ±0.1 kg. The athlete stepped onto the platform barefoot and without socks, maintaining an upright, aligned, and static posture. Height was measured using a portable stadiometer (SECA model 213) with a scale of 0 cm to 2.20 m with an accuracy of ± 0.1 cm. For the

evaluation, the athlete was barefoot, without socks, and leaning straight against the surface of the stadiometer, the head position was in the Frankfurt plane, and the body was in an appropriate posture. Sitting height: a wooden anthropometric bench was used (50 cm long × 40 cm high × 30 cm wide) according to the characteristics recommended by the ISAK manual. The measurement was taken from the highest point of the head (vertex) to the surface of the bench. The athlete was seated with their back straight, in an inspiratory position, without shoes, and with their legs at a right angle. The time was recorded with a Casio brand digital stopwatch, model HS 80TW. Stopwatch accuracy: 99.9988% and time ±30" per month.

Elbow Plank: This is an isometric exercise in which the body is held in a horizontal position for as long as possible. It begins with the forearms pronated and the balls of the feet supported, keeping the core engaged to maintain a straight alignment from the shoulders to the ankles. Attention was paid to errors such as lowering the hips, raising the buttocks too high, collapsing the shoulders, maintaining tension in the neck, or holding one's breath. These errors compromise proper posture.

Before starting with the elbow for the plank exercise, a ten-minute warm-up was performed to activate neuromuscular muscles. Three attempts were made, with a three-minute rest period between each attempt for recovery. The best result was recorded.

Prior to the physical assessments, participants received an explanation of the research's purpose, objectives, and procedures. Parents or guardians were also asked to sign an informed consent form authorizing their children's participation. This process was conducted in accordance with the ethical principles established in the Declaration of Helsinki for research involving human subjects.

To ensure accurate data collection by the evaluators, a pilot test was conducted with the same group. Data collection was supervised by a physical education teacher experienced in this type of assessment. Participation in the study was voluntary.

Statistical analysis was performed using the open-source software R version 4.4.1, and consisted of two parts: in the descriptive phase, the mean, standard deviation, and variance were calculated to describe the average value of each variable according to sex and to characterize the overall behavior of each group with respect to the physical and performance variables evaluated. In the inferential statistics, Student 's t-test was applied to determine if the differences were significant.

The p- value was used to interpret the differences, considering the degrees of freedom according to the size of each group.

## *RESULTS AND DISCUSSION*

Decimal age was calculated by subtracting the age at birth from the age on the day of assessment. The Mirwald formula was used to determine maturity (peak growth velocity. Mirwald *et al.* (2002), also called " Maturity Offset". This method predicts the distance in years from the moment of greatest growth velocity in height, using age, height, weight, leg length (seated height was subtracted from height) and seated height, allowing us to know what stage of physical maturation the athlete is in, something very useful to adapt training according to the development of each person.

For men:

Maturity Offset = -9.236 + 0.0002708 * (Leg Length * Sitting Height) - 0.001663 * (Age * Leg Length) + 0.007216 * (Age * Sitting Height) + 0.02292 * (Weight / Height).

For women:

Maturity Offset = -9.376 + 0.0001882 * (Leg Length * Sitting Height) + 0.0022 * (Age * Leg Length) + 0.005841 * (Age * Sitting Height) - 0.002658 * (Age * Weight) + 0.07693 * (Weight / Height).

Body fat percentage (%BF) was estimated using the Deurenberg formula, which considers body mass index (BMI), age, and sex. This formula provides an indirect estimate of fat mass (FM) and, by difference, fat-free mass (FFM), which includes muscle, bone, organs, and body fluids. The formula used was: %BF = (1.51 × BMI) − (0.70 × age) − (3.6 × sex) + 1.4; where sex is coded as 0 for females and 1 for males. From this result, FM was calculated as (%BF / 100) × weight, and FFM as total weight minus fat mass. BMI was calculated using the Quetelet formula (weight/height²) expressed in kg/m² (Deurenberg). *et al.,* 1991, cited in Bauce, 2022; Llamosas, 2020; Flores, 2021; Mill *et al.,* 2020).

Although chronological age was similar between women (13.85 years) and men (13.89 years), the results for growth velocity (GHV) revealed a highly significant difference ($t = -9.83$, $p < 0.0001$): males had already passed their peak growth velocity (with a mean value of –0.16), while females were approximately 2.66 years away from reaching it. This confirms the biological growth gap between the sexes during adolescence.

Regarding height, a significant difference was found ($t = -3.90$, $p = 0.00063$), with males being taller, which aligns with the results of the maturity state

Regarding body composition, men showed significantly more fat-free mass ($t = -4.52$, $p = 0.00013$), while women presented a significantly higher percentage of fat than men ($t = 2.24$, $p = 0.03434$), as well as greater fat mass in kilograms ($t = 5.17$, $p = 0.00007$). This is related to associated muscle development and maturational advancement.

Core strength test (elbow) No significant differences were found between the plank test and BMI ($t = 0.93$, $p = 0.3585$), with both sexes showing similar times ($t = 0.94$, $p = 0.3536$). Finally, body weight showed a tendency to be higher in men, although this did not reach statistical significance ($t = -1.51$, $p = 0.142$). See results in Table 1.

***Table 1. -*** *Comparison of anthropometric and physical performance variables between adolescent males and females*

| Variables | Men (n=15) | | Women (n=15) | | Test for difference of means | | |
|---|---|---|---|---|---|---|---|
| | X | OF | X | OF | Statistics (t) | p- value | gl |
| Age (years) | 13.89 | 0.45 | 13.85 | 0.55 | -0.19147 | 0.84932 | 27.78 |
| Maturity State (PVH) | 2.66 | 0.93 | -0.16 | 0.66 | -9.83333 | <0.0001 | 24.91 |
| **Anthropometry** | | | | | | | |
| - Weight (kg) | 65.54 | 10.47 | 59.45 | 11.87 | -1.51487 | 0.14204 | 27.02 |
| - Height (m) | 1.67 | 0.08 | 1.56 | 0.10 | -3.89787 | 0.00063 | 27.21 |
| - BMI (kg/m²) | 23.4 | 3.22 | 24.67 | 5.66 | 0.93453 | 0.35852 | 22.40 |
| **Evidence** | | | | | | | |
| - Elbow plank ( sec ) | 93.87 | 49.88 | 108.40 | 39.76 | 0.94433 | 0.35362 | 26.67 |
| **Body composition** | | | | | | | |
| - % Fat ( Deurenberg ) | 23.4 | 5.01 | 28.95 | 8.40 | 2.24133 | 0.03434 | 22.86 |
| - Fat Mass (kg) | 35.67 | 5.16 | 48.39 | 9.56 | 5.16933 | 0.00007 | 21.53 |
| - Fat Free Mass (kg) | 29.87 | 11.47 | 11.07 | 13.91 | -4.52000 | 0.00013 | 27.02 |

*Note. Values represent means (X) and standard deviations (SD). BMI = Body Mass Index; PVH = Peak Height Growth Velocity (PHV) Height Velocity); independent samples t-test; physical performance was assessed using the isometric elbow endurance test Planck. Significance level: p < .05.*

Upon observing the results, a significant inverse relationship was found between performance on the elbow test plank and two indicators of adiposity: BMI and body fat percentage. Although fat-free mass also showed an inverse trend, it was not statistically significant. BMI explains 29.3% of the variation in strength in the elbow test. The plank, which is statistically significant, given that its confidence interval does not include 0. That is, a higher BMI is associated with lower performance. Body fat percentage also shows a similar correlation ($r^2$ = 27.9%), suggesting that adiposity is a determining factor in isometric performance in men. Total fat mass, although negatively correlated, only explains 3.3% of the variance, which is not significant. Fat-free mass, despite having an r = -0.424, is not significant, and its interpretation is limited by the interval [-0.769, 0.113]. This makes sense considering that more body mass implies more weight to stabilize, and that requires more core tension.

In the women's results, no variable reached statistical significance, as all confidence intervals included 0. The variable with the highest $r^2$ was fat mass (9.3%), suggesting a possible trend: greater fat mass is associated with shorter plank times, but this is not conclusive. Fat-free mass (muscle) showed a positive correlation, suggesting that more muscle may be associated with greater endurance, although the confidence interval indicates that this cannot be stated with 95% confidence.

This makes sense when we remember that BMI doesn't distinguish between muscle and fat. In men, who on average have more lean mass, it can better reflect functional status. However, in women, where body composition and distribution are much more diverse (subcutaneous and visceral fat, hormonal changes, fluid retention), it loses accuracy.

Another reasonable expectation was that fat-free mass, which includes muscle, would correlate well with plank performance, which requires strength, control, and endurance. But the numbers did not confirm this, as can be seen in the results in Table 2.

***Table 2. -*** *Results of correlations between elbow plank and body variables*

| Indicators | Elbow plank man | | | Elbow plank women | | |
|---|---|---|---|---|---|---|
| | r | $r^2$ | 95% confidence level | r | $r^2$ | 95% confidence level |
| - BMI ($kg/m^2$) | -0.541 | 0.292681 | [-0.825, -0.040] | -0.174 | 0.030 | [-0.630, 0.371] |
| - % Fat ( Deurenberg ) | -0.528 | 0.278784 | [-0.819, -0.021] | -0.169 | 0.029 | [-0.627, 0.375] |
| - Fat Mass (kg) | -0.182 | 0.033124 | [-0.635, 0.364] | -0.304 | 0.093 | [-0.706, 0.246] |
| - Fat Free Mass (kg) | -0.424 | 0.179776 | [-0.769, 0.113] | 0.242 | 0.058 | [-0.309, 0.671] |

***Note:*** *Pearson correlation coefficients (r), coefficient of determination ($r^2$), and 95% confidence intervals are presented for each variable. BMI = Body Mass Index; % Fat = Percentage of fat estimated by the Deurenberg formula; Fat Mass and Fat-Free Mass in kilograms. Correlations with $p < .05$ are considered statistically significant.*

The findings show a significant negative association between the elbow Plank and adiposity in men: BMI explained 29.3% and body fat percentage 27.9% of the variance in endurance time. In contrast, fat-free mass did not show a significant correlation, possibly due to the simultaneous increase in total body weight. In women, no variable was statistically significant, although a slight trend was detected between greater fat mass and shorter plank time. These differences could be explained by physiological and hormonal factors that influence core stability differently between sexes.

The interpretation of these results suggests that excess body fat acts as an extra load that hinders isometric stability in the plank. This supports the role of the core as a trunk stabilizer and force transmitter (Tafakoriollah. *et al.,* 2020). Fat-free mass did not show a significant correlation, possibly because, as it increases, it also raises total body weight, which can negate its benefits if there is not an adequate muscle-to-fat ratio (Laurson, 2022). Bai *et al.* (2007) also demonstrate that training can raise BMI and lean mass without reducing fat ($p < 0.05$), highlighting the need to assess body composition holistically.

In addition, previous studies have also identified negative associations between body fat and core performance. Karataş (2024) found a negative correlation between BMI and core strength in men ($r = –0.566$; $p < 0.001$) and women ($r = –0.63$; $p = 0.002$). Laurson (2022) observed that 90% of adolescents with a higher proportion of lean mass achieved better plank times. Vukadinovic *et al.* (2024) and Lasković (2022) also reported that greater muscle mass and lower body fat are associated with better physical performance. Choi *et al.* (2025) showed that muscle activation in

the plank varies according to sex and stability, which supports the differences found in this study. Finally, Noel (2020) highlighted the plank as a key functional test due to its relationship between the core and the upper extremity, useful for assessing performance and injury risk.

Core stability, especially in men, where BMI explained 29.3% and body fat percentage 27.9% of the poor plank performance. This confirms the value of the elbow. The plank exercise is used as a functional diagnostic tool linked to body composition. In sports, these results support the need for programs that improve the lean mass/fat ratio to optimize core strength (Salcedo, 2021; Gálvez *et al.,* 2022), also integrating biomechanical and postural control aspects beyond absolute strength.

## *CONCLUSIONS*

The more body fat men have, the less time they can withstand the elbow strain. plank (whether measured by BMI or a specific percentage), which conclusively confirms: more fat means less resistance. This suggests that excess adipose tissue can limit core stability. In contrast, no significant relationship was observed in women, which could be explained by differences in maturational, hormonal, and muscular development typical of this stage of puberty.

For women, the results were different: although a certain trend was observed (more fat, lower performance; more muscle, better performance), this relationship was not sufficiently clear in our study. For now, we cannot conclude that their body composition determines how long they can endure the elbow test. plank.

Therefore, these results allow us to conclude that body profile can indeed influence performance in core stability exercises, especially in young athletes undergoing pubertal transition, and promoting a healthy body composition could improve performance in core stability exercises such as the elbow raise. plank, benefiting both injury prevention and comprehensive physical preparation in adolescent athletes.

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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.