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Correlation between strength, muscle mass, and ROM of the deltoid muscle in sport enthusiasts

Correlación entre la fuerza, masa y ROM del músculo deltoides en deportistas aficionados

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Abstract

Deltoid muscle has an important role in shoulder stabilization and mobility, especially in sports enthusiasts who are active in various sports. An imbalance between muscle strength, muscle mass, and shoulder joint flexibility can increase the risk of injury and reduce performance. This study aims to analyze the correlation between deltoid muscle strength with arm muscle mass, and shoulder range of motion (ROM) in sport enthusiasts. This study is a cross-sectional observational study involving 31 sport enthusiasts, 11 hombres y 20 mujeres with characteristics of (age 23.10 ± 3.57 years, height 163.61 ± 7.21 cm, body mass 60.27 ± 9.71 kg, and BMI 22.46 ± 3.48 kg/m²). The data were analyzed using Spearman's rho test. There was a significant correlation between deltoid muscle strength and arm muscle mass in the right ($p = 0.009$; $r = 0.459$) and left ($p < 0.001$; $r = 0.626$) arms. In addition, left arm deltoid strength was significantly correlated with left shoulder ROM ($p = 0.003$; $r = 0.514$), however no significant relationship was found between muscle strength and ROM in the right arm. The results show the importance of an integrated evaluation of strength, muscle mass and joint mobility in designing safe and effective exercise programs. These findings can serve as a basis for trainers and therapists in preventing injury and optimizing shoulder functional performance in sport enthusiasts.

Keywords: deltoid; muscle; strength; range of motion

Resumen

El músculo deltoides desempeña un papel importante en la estabilización y la movilidad del hombro, especialmente en los aficionados al deporte que practican diversas disciplinas. Un desequilibrio entre la fuerza muscular, la masa muscular y la flexibilidad de la articulación del hombro puede aumentar el riesgo de lesiones y reducir el rendimiento. El objetivo de este estudio es analizar la correlación entre la fuerza del músculo deltoides, la masa muscular del brazo y el rango de movimiento (ROM) del hombro en aficionados al deporte. Se trata de un estudio observacional transversal en el que participaron 31 aficionados al deporte, 11 hombres y 20 mujeres, con las siguientes características (edad $23,10 \pm 3,57$ años, altura $163,61 \pm 7,21$ cm, masa corporal $60,27 \pm 9,71$ kg e IMC $22,46 \pm 3,48$ kg/m²). Se realizaron mediciones de la fuerza del músculo deltoides, la masa muscular del brazo y el rango de movimiento (ROM) del hombro utilizando (Vald DynaMo) y la composición corporal (báscula digital Onpoint axis), y los datos se analizaron mediante la prueba de Spearman. Se observó una correlación significativa entre la fuerza del músculo deltoides y la masa muscular del brazo derecho ($p = 0,009$; $r = 0,459$) e izquierdo ($p < 0,001$; $r = 0,626$). Además, la fuerza del deltoides del brazo izquierdo se correlacionó significativamente con el ROM del hombro izquierdo ($p = 0,003$; $r = 0,514$), sin embargo, no se encontró una relación significativa entre la fuerza muscular y el ROM en el brazo derecho. Los resultados muestran la importancia de una evaluación integrada de la fuerza, la masa muscular y la movilidad articular en el diseño de programas de ejercicio seguros y eficaces. Estos hallazgos pueden servir de base a los entrenadores y terapeutas para prevenir lesiones y optimizar el rendimiento funcional del hombro en los aficionados al deporte.

Palabras clave: deltoides; músculo; fuerza; rango de movimiento

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Introduction

Sport enthusiasts are individuals who pursue sports professionally or recreationally (Zwarycz, 2020). The current era shows an increasing trend in sports activities in various sports such as padel, tennis, badminton, pilates, swimming and other functional sports (Sánchez-Alcaraz & Courel-Ibáñez, 2022). In these sports, the shoulder is one of the main body parts that is most functional due to its role in stabilization and dynamic movements of the arm (Ramasamy et al., 2022). Moreover, the deltoid muscle, a large muscle that lines the shoulder and plays an important role in almost all upper extremity movements, especially in abduction, flexion, extension and rotation of the arm (Koch et al., 2021). However, many cases in sports enthusiasts experience limitations in shoulder mobility and even pain due to imbalances in strength or muscle mass in the area (Haratian et al., 2021). Although various exercise programs are dedicated to training and strengthening the deltoid muscle, there are still high cases of injuries experienced by sports enthusiasts without the guidance of professional trainers (Goes et al., 2020). The mismatch between deltoid muscle strength and arm muscle mass and range of motion (ROM) is often overlooked by most people, which is why it is important to further understand the relationship between these parameters in the context of physical activity in sport enthusiasts (Lijewski et al., 2021).

Shoulder problems such as pain, dislocation, and limitation of motion should be a serious concern among sports enthusiasts from various sports (Salamh et al., 2023). For example, individuals who experience injuries to the deltoid muscle or shoulder ROM limitations that will result in inhibition during exercise performance and will potentially decrease motivation to continue performing sports activities as well (Xu, 2023). In addition, many sports enthusiasts perform exercises without a deep understanding of muscle and joint biomechanics, which can increase the risk of musculoskeletal disorders (Teferi & Endalew, 2020). The lack of specific scientific information regarding the relationship of deltoid muscle strength with arm muscle mass and shoulder ROM makes this issue even more urgent to study. Amidst the increasing trend towards a healthy lifestyle, attention to quality of movement and injury prevention should be a priority (Kozlenia & Domaradzki, 2021). If not treated appropriately, impaired shoulder function can lead to long-term problems that impact quality of life (Lee & Stubblefield, 2024).



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Therefore, research is needed that can serve as a reference for sports enthusiasts and coaches in designing more effective and safe training programs.

One preventative measure that can be taken is to conduct an in-depth evaluation of the correlation between deltoid muscle strength, arm muscle mass and shoulder ROM. By understanding the relationship between these variables, training programs can be tailored to optimally improve shoulder stability and mobility. For example, sports enthusiasts in sports such as tennis and swimming that rely on high shoulder mobility and endurance, require muscle strengthening that focuses not only on size but also motion functionality (Zemková & Zapletalová, 2022). Objective measurements and using appropriate SOPs regarding deltoid muscle strength and ROM can help in detecting potential risks earlier (Mindova et al., 2019). In addition, the development of exercise programs based on the results of this study can help sports enthusiasts to avoid the risk of injury and monotonous training (Steib et al., 2017). Physical therapy and customized muscle strengthening programs can also be determined more precisely based on the correlation results found. Therefore, a scientific approach to the correlation between muscle strength, muscle mass, and shoulder joint flexibility is needed as a long-term solution.

This study aims to analyze the correlation between deltoid muscle strength with arm muscle mass and shoulder ROM in sport enthusiasts from various sports. This goal is based on the importance of a comprehensive understanding of the role of the deltoid muscle in supporting upper extremity functional performance. This study is also expected to provide objective data as a reference for consideration in the preparation of training and rehabilitation programs for sports enthusiasts. In addition, the results of this study can assist coaches and therapists in identifying biomechanical factors that contribute to shoulder performance and injury risk. Thus, sports enthusiasts in various segments, both those who are just starting out and those who have been involved in sports for a long time, can practice more safely and effectively. In addition, this study also aims to add to the relevant scientific literature in the field of sports health, especially those related to the shoulder. Overall, this research is a systematic effort to improve the quality of sports activities through a better understanding of muscle anatomy and functionality (Oliva-Lozano & Muyor, 2020).



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Methodology

Research Design

This research design is observational study cross-sectional correlation type, with data collection in this study began with tests of shoulder ROM and deltoid muscle strength in both arms. Then the body composition test was carried out to determine body mass, BMI, and arm muscle mass. Raw data consisting of age, height, body mass, BMI, arm muscle mass, deltoid muscle strength, and shoulder mobility were collected and selected as needed into Microsoft excel. After selecting the data as needed. The test results and measurements of the subjects were analyzed using SPSS software version 26, a normality test was performed using the Saphiro-Wilk method, with a significance value ($p\text{-value} > 0.05 = \text{normally distributed data}$). Then the Spearman's rho test analysis was used to analyze the relationship between variables as a whole with a significance value ($p\text{-value} < 0.05 = \text{there is a significant relationship}$).

Study Participants

The population of this study consisted of sports enthusiasts who regularly engaged in various types of sports activities, either professionally or recreationally. A total of 31 participants were included, comprising 11 males and 20 females (7 males are right handed, 4 are left handed, 15 females are right handed, 4 are left handed, and 1 female is balance), with the following characteristics (age 23.10 ± 3.57 years, height 163.61 ± 7.21 cm, body mass 60.27 ± 9.71 kg and BMI 22.46 ± 3.48 kg/m²). All subjects met the inclusion criteria: (1) an interest or hobby in sports, and (2) being in healthy physical condition without any upper extremity injuries that could affect the test results. The exclusion criteria were: (1) current illness or injury, and (2) age below 19 or above 32 years. Ethical approval was granted by the ethics committee (013/UN38.10/EC.KEPK/HK.01.02/2025)



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Study Organization

The data collection stage in this study used two test instruments consisting of measuring deltoid muscle strength and shoulder mobility using a Vald DynaMo (Brisbane, Australia). This tool is a measurement instrument with high validity because the Vald DynaMo is an intuitive, efficient data collection tool, and is supported by a compact ergonomic design that allows evaluation of strength and range of motion in every part of the body (Oxford et al., 2024). In addition, body composition measurements use bioelectrical impedance analysis Onpoint Axis (China).

Before starting the measurement, the instrument will first be connected to the device that has the dynamometer application installed, then the subject's personal data will be entered consisting of ID and date of birth. Furthermore, before taking measurements, the subject is required to warm up first with a dynamic warm-up which aims to avoid unwanted injuries during the measurement process. After the subject has finished doing dynamic warm-up, the subject is asked to stand upright with a forward glance and both arms in a neutral position which will be fitted with velcro on the forearm. Then the Vald DynaMo will be attached to the velcro and must face sideways. After the device is installed and has been synchronized to the software (zero degree calibration), the subject is instructed to perform shoulder abduction movements as much as possible with a note that there should be no compensation from the torso leaning to the side and the elbow being bent. During the measurement process the subject should not rotate the arm forward or backward which will affect the results. Measurements will be repeated twice and performed on both arms.

After completing the measurement of the range of motion (ROM) of the shoulder, it will be continued with the measurement of deltoid muscle strength (Calibration of zero newtons and will be converted to kg for data processing). The subject is required to stand upright with a straight forward view and neutral arm position. Then the Vald DynaMo will be held by the tester parallel to the subject's forearm. Furthermore, the subject is asked to make a fist on one hand which will be measured for deltoid muscle strength. After the subject is ready, he will be instructed to perform a shoulder abduction movement pushing the tool held by the tester as much as possible for 5 seconds. The movement will be done for two repetitions on the right and left arms. From the measurement of shoulder



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mobility and deltoid muscle strength, the highest value of both repetitions will be taken and the measurement results will appear on the connected software.

The next stage involves the measurement of body composition. Before beginning the measurement, it is essential to ensure that the instrument is connected to the software via the Unique Health application, and that the subject's personal data, including ID, date of birth, and height, have been entered. The subject is then instructed to remove all metal accessories, empty any objects from their pockets, and take off their footwear. Next, the subject is asked to step onto the device and grasp the handles equipped with metal electrodes, maintaining an upright posture with their gaze forward and both arms extended straight ahead, parallel to the chest. The subject is required to hold this position throughout the measurement, which takes approximately thirty seconds. Upon completion of the measurement, the results including body mass, muscle mass, fat mass, BMI, and other variables are displayed on the connected software.

Results

Table 1 shows the descriptive test results of the body composition of sports enthusiasts which show the age value (23.10 ± 3.57 years), height (163.61 ± 7.21 cm), body mass (60.27 ± 9.71 kg), and BMI (22.46 ± 3.48 kg/m²). Whereas in MM RA (2.10 ± 0.47 kg) after conducting a normality test showed a p-value (0.012) which means the data was not normally distributed, and MM LA (2.05 ± 0.47 kg) after conducting a normality test showed a p-value (0.017) which means the data was not normally distributed.

Table 1. Descriptive results of the body composition

Variable	Mean $\pm$ SD	p
Age	23.10 $\pm$ 3.57	0.001
Height (cm)	163.61 $\pm$ 7.21	0.334
Body mass (kg)	60.27 $\pm$ 9.71	0.932
BMI (kg/m ²)	22.46 $\pm$ 3.48	0.326
MM RA (kg)	2.10 $\pm$ 0.47	0.012
MM LA (kg)	2.05 $\pm$ 0.47	0.017

Note. MM: Muscle Mass, RA: Right Arm, LA: Left Arm

Table 2 shows the descriptive test results of ROM on the right arm and left arm with the RA ROM value (180.03 ± 14.59 °) after conducting a normality test showing a



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p-value (0.996) which means the data is normally distributed. While at ROM LA ($176.03 \pm 8.80^\circ$) after conducting a normality test shows a p-value (0.016) which means the data is not normally distributed. Then at DMS RA (8.88 ± 2.57 kg) after doing the normality test shows a p-value of 0.320 which means the data is normally distributed, and at DMS LA strength (8.67 ± 2.81 kg) after doing the normality test shows a p-value of 0.007 which means the data is not normally distributed.

Table 2. Descriptive Results of the Normality Test for Shoulder ROM and Strength

Variable	Mean $\pm$ SD	p
RoM RA	180.03 $\pm$ 14.59	0.996
RoM LA	176.03 $\pm$ 8.80	0.016
DMS RA	8.88 $\pm$ 2.57	0.320
DMS LA	8.67 $\pm$ 2.81	0.007

Note. ROM: Range of Motion, DMS: Deltoid Muscle Strength

Table 3 shows the correlation test between DMS with MM and ROM in sports enthusiasts. There are results that show a correlation in DMS RA and DMS LA where DMS RA correlates with MM RA (p-value 0.009 and r-value 0.459) has a significant correlation and is classified as low, while DMS RA with ROM RA does not show a significant correlation. In DMS LA shows a correlation with MM LA (p-value <0.001 and r-value 0.626) has a moderate correlation, and in DMS LA with ROM LA (p-value 0.003 and r-value 0.514) has a correlation that is classified as low.

Table 3. Statistical Results Correlation DMS with MM and ROM

	MM RA	MM LA	ROM RA	ROM LA
DMS RA	0.009 r=0.459	-	NS	-
DMS LA	-	<0.001 r = 0.626	-	0.003 r = 0.514

Note.DMS=Deltoid muscle strength, MM=Muscle mass, ROM=Range of motion



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Discussion

The results of this study indicate that there is a significant correlation between deltoid muscle strength (DMS) and arm muscle mass (MM) in both the right arm ($p = 0.009$, $r = 0.459$) and left arm ($p < 0.001$, $r = 0.626$), with the correlation level classified as low and moderate respectively. In addition, left arm deltoid muscle strength also showed a significant correlation with left shoulder ROM ($p = 0.003$, $r = 0.514$) which was classified as low, however in the right arm no significant correlation was found between DMS and ROM. Overall these findings suggest that increased muscle mass contributes to increased deltoid muscle strength, and that shoulder joint flexibility also has a relationship with muscle strength functionally, at least on the side of the body that is non dominant or rarely used by the subjects. Therefore, these findings support several previous studies showing a significant relationship between muscle mass and muscle strength in the upper extremity (Kołodziej et al., 2020). Research conducted by (Rau et al., 2022) stated that increased arm muscle mass was positively correlated to shoulder muscle isometric strength in 11 male and 11 female volunteers. Meanwhile, research by (Escamilla & Andrews, 2009) emphasizes that deltoid muscle strength is closely related to joint performance and stability during abduction and flexion movements in baseball when throwing a ball. However, some studies, such as those conducted by (Jung et al., 2021) mention that ROM does not always correlate with muscle strength, especially in individuals with joint stiffness or biomechanical limitations, such as adults. In this context, the results of this study indicate that the correlation between ROM and DMS is only significant in the left arm, suggesting an imbalance in muscle use or dominance among sports enthusiasts, a topic that has not been systematically addressed in previous research.

The implications of this research are highly relevant in the fields of sports and rehabilitation, particularly in designing evidence-based training programs (Lindsay et al., 2023). Understanding the relationship between deltoid muscle strength and upper arm muscle mass can assist coaches or physical therapists in adjusting exercise intensity to achieve optimal functional outcomes for the shoulder joint (Campos et al., 2020). Additionally, the correlation found between DMS and ROM in the left arm underscores the importance of evaluating both sides in posture and biomechanical analysis, rather than

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focusing solely on the athlete's dominant side. Therefore, shoulder injury prevention programs should also consider overall muscle strength and flexibility balance (Hoppe et al., 2022). This study contributes to clarifying that muscle mass is not the sole indicator of strength but should be analyzed alongside functional parameters such as ROM (Detiana et al., 2023). However, this study only measured shoulder abduction movements and did not include other movements such as adduction or rotator cuff movements (internal and external rotation), which were limitations of this study. Therefore, future studies should incorporate these movements, increase the number of subjects, and focus on a sport that relies on upper extremity performance. Additionally, this study paves the way for future longitudinal designs to monitor muscle strength and changes in ROM in response to long-term sports interventions. Furthermore, stronger results could be achieved by testing populations with more balanced age and gender distributions.

Overall, these findings emphasize the importance of a holistic approach in evaluating muscle and joint performance by integrating physical evaluation and biomechanical analysis in sports enthusiasts (Sharick Shamsi et al., 2024). In line with this, global trends in recreational sports and functional fitness necessitate data-driven and personalized rehabilitation and training approaches (Cao et al., 2023). Moving forward, the use of portable technologies such as handheld dynamometers and bioimpedance analysis has the potential to revolutionize methods for evaluating muscle-joint conditions in broader training environments. Thus, as interest in fitness continues to grow, such research will play a crucial role in bridging science and field practice. From a technological and methodological perspective, the use of the Vald Dynamometer and Onpoint Axis demonstrates how modern devices can provide accurate and practical measurements in the context of muscle strength and body composition evaluation (Gaudet & Handrigan, 2020). Moreover, the use of these instruments not only enhances data validity but also facilitates replication and monitoring of athletes' progress in long-term training programs (Staff et al., 2023). Finally, this instrument-based approach enables the integration of biomechanical measurement techniques with the practical needs of sports enthusiasts, while contributing to the development of clinically and technically relevant functional measurement tools (Irawan et al., 2024).

Conclusion



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This study demonstrates a significant correlation between deltoid muscle strength and upper arm muscle mass, as well as a more limited correlation with shoulder range of motion (ROM), particularly in the left arm. These findings highlight the importance of considering the balance between muscle strength, muscle mass, and joint mobility in supporting athletic performance and injury prevention, especially for sports enthusiasts across various disciplines. These results also provide a scientific basis for coaches and therapists in designing more targeted and safe training programs. This study concludes that contributes to the development of sports science and opens opportunities for further research on shoulder biomechanics in the context of physical activity. In the future study, the subject will be increasing and divided by gender it could be support in specific male or female.

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