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ARTICLE

Effects of strength training on body structure and muscle development in female basketball players: A case study of the NUM "falcons" team

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Abstract: This study aimed to evaluate the effects of a structured strength training program on body structure and muscle development in female basketball players, using the NUM's "Falcons" team as a case study.

The study was conducted with 13 female athletes from the Shonkhoruud (Falcons), the women's basketball team of the National University of Mongolia (NUM). Over a four-month period, the athletes followed a structured strength training program that incorporated both general and functional exercises using bodyweight and external resistance. Anthropometric data related to body structure and muscle mass were collected using 13 specific indicators at three period points: baseline (0 months), mid-point (2 months), and post-intervention (4 months). The data were analyzed using Repeated Measures ANOVA to identify statistically significant changes over time.

The analysis revealed statistically significant changes in several anthropometric indicators. Specifically, the shoulder circumference increased by 1.6 cm, the upper arm circumference by 1.3 cm, and the waist circumference decreased by an average of 2.9 cm ($p<0.05$). These findings demonstrate that a structured strength training program can significantly enhance muscle development and improve body composition and structure in female basketball players. The study supports the inclusion of targeted strength training as an effective component of athletic development for female athletes.

Keywords: *training program, physical development, muscle circumference, muscle mass, strength training, female basketball players;*

INTRODUCTION

Basketball is a widely played sport on a global scale with over 450 million players registered by FIBA, which unites more than 200 national associations worldwide [11]. The rapid development of basketball is inextricably linked to players' technique, tactics, psychology, movement skills, and anthropometric indicators [4, 9]. During a single game, players run an average of four kilometers, jump approximately 46 times, and change movement direction more than 1,000 times [7, 20].

Therefore, stamina, speed, agility, strength, and muscular responsiveness must all be highly developed. Players' body measurements, structure, and composition not only influence performance, but also serve as major predictors of whether they can reach elite levels [3, 18, 22].

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Vol. 64 No 02(254) 2025
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In basketball, body size and anthropometric characteristics affect performance differently across playing positions. For example, players with tall stature and large body size, particularly those playing in the center and power forwards positions, are more effective in close-range defensive skills, such as rebounding and shot-blocking.

Conversely, smaller-sized guards tend to excel in speed, quick passing, and offensive execution [8]. Therefore, skill performance must be closely aligned with physical development and positional demands [31].

In recent years, a growing body of research has studied the relationship between physical ability and athletic success across various sports disciplines, including American football [12, 5], soccer [2], rugby [21], Australian football [29], field hockey [16], volleyball [14], and basketball [15, 23].

Physical ability is of immense significance in basketball performance. Players are expected to sustain high-intensity efforts until the end of the game and possess the ability to combine technical and tactical actions effectively [13, 30].

However, the majority of recent studies have focused on male athletes, and there remains a lack of data regarding the physical characteristics and developmental trends of female basketball players.

This article presents the findings of a study that examined the effects of a structured strength training program designed to enhance muscle mass and improve physical development in female basketball athletes.

Study purpose*:* This study aimed to evaluate the effects of a structured strength training program on body composition and muscle development in female basketball players.

Research objectives

- To measure athletes' weight, height, body mass index (BMI), and body circumferences at three time points.
- To design and implement a strength training program to increase muscle mass.
- To analyze the measurement outcomes using Repeated Measures ANOVA in SPSS to assess statistical significance.

Study hypothesis: The strength training program will show statistically significant results in female players' muscle mass and body structure (circumference measurements).

MATERIALS AND METHODS

The study employed the following methodologies:

- *Literature analysis:* Relevant books, data, and scientific references were reviewed to establish the theoretical foundation of the study.
- *Pedagogical observation:* Observations were conducted on athletes' participation, training intensity, and progression.
- *Pedagogical testing:* A strength training program was implemented, and pre- and post-intervention outcomes were compared.
- *Anthropometric measurements*: Body composition indicators were assessed using standard anthropometric techniques.
- *Statistical analysis:* Changes over time were evaluated using Repeated Measures ANOVA.
- *Interpretation:* Results were analyzed, and corresponding conclusions and recommendations were formulated.

Study Participants: Thirteen female athletes from the NUM *"Falcons"* basketball team participated in the study. The average age of the participants was 18.62 ± 3.14 years, with an average height of 171 ± 8 cm and an average weight of 64.9 ± 5 kg. All participants were university students ranging from freshman to senior levels. On average, they engaged in 10 hours of basketball practice and 6 hours of strength training per week.

Vol. 64 No 02(254) 2025
DOI: - https://doi.org/10.5564/pmas.v65i02.4391

Study Phases

Phase 1. Baseline Anthropometric Measurements (21 November 2022):

1. Body weight measured using a Tanita HD-314W digital scale (USA).
2. Height measured with a Marsden T-226 stadiometer (UK).
3. Body mass index (BMI) calculated using the formula: BMI = weight (kg) / height² (m²).
4. Circumferences of the shoulders, chest, upper arms (left and right), waist, buttocks, thighs, and shins measured with a Lufkin flexible tape (Germany) to the nearest 0.1 cm. Measurements were taken at three time points: baseline (0 months), mid-point (2 months), and post-intervention (4 months).

Phase 2. Training Program Implementation: A customized strength training program aimed at increasing muscle mass was developed and implemented over a 4-month period, with a frequency of 6 hours per week.

Phase 3. Mid-term Assessment (21 January 2023):

Interim measurements and evaluations were conducted. Feedback was provided, and program adjustments and recommendations were made based on the interim results.

Phase 4. Final Assessment (21 March 2023):

After four months of training, final measurements were taken, including changes in muscle mass, body structure, and BMI. Data were then statistically processed using appropriate methods.

Table 1. Baseline physical development indicators of NUM "Falcons" female basketball players.

Players' positions	Height /cm/	Body weight /kg/	BMI	Shoulder circumference /cm/	Chest circumference /cm/	Right upper arm /cm/	Left upper arm /cm/	Waist circumference /cm/	Buttocks circumference /cm/	Right thigh circumference /cm/	Left thigh circumference /cm/	Right shin circumference /cm/	Left shin circumference /cm/
Center C /5/	180	69.0	21.3	102	90.5	30	28	75.5	102	60	60	36.5	36.5
Power Forward PF /4/	172.4	64.4	20.9	101	86.2	28	27.4	73.9	97.4	58	56.7	36.9	36.2
Small Foward SF /3/	167	65.0	23.3	104	88	30	29	78	100	58	60	37	35
Shooting Guard SG /2/	170	64.8	22.3	106	89.8	27.8	28.5	75	100	58	59	37	37
Point Guard PG /1/	167	63.0	22.9	101	86.5	30	29	79	98	58	60	36	36
Average results	**171**	**65.2**	**22.1**	**103**	**88.2**	**29.2**	**28.3**	**76.3**	**99.4**	**58.4**	**59.1**	**36.7**	**36.1**

Body mass index (BMI) – Features by position:

The BMI of study participants was calculated using SPSS, and most players fell within the World Health Organization's normal range (18.5–24.9). For example, a player weighing 67 kg with a height of 1.80 m has a BMI of 20.7.

Initial measurements (0 month) showed BMI variations based on playing positions: *Center (C):* BMI 21.3 – tall, lean build, advantageous for height-dependent defensive roles, such as rebounding and shot blocking.

Vol. 64 No 02(254) 2025
DOI: - https://doi.org/10.5564/pmas.v65i02.4391

Power Forward (PF): BMI 20.9 – appropriate for physically demanding roles, but indicates the need for increased muscle mass.
Small Forward (SF): BMI 23.3 – well-developed physique, suitable for positions requiring both speed and power.
Shooting Guard (SG): BMI 22.3 – within normal range, but a leaner build may better support speed and agility.
Point Guard (PG): BMI 22.9 – nearing upper limit of normal; but this position requires speed and ability to swiftly change directions; therefore, even a small increase in body weight might adversely affect performance.

Although all players were within the normal BMI range, observed differences in muscle mass and role-specific physical demands emphasize the need for position-tailored strength training.

Training results of the study performed on the NUM "Falcons" female basketball team

The structured strength and basketball training program for the NUM "Falcons" female basketball team was implemented over a four-month period (December to March), with a total of 224 planned hours. The training content included general training (14.3%), special physical training (26.8%), basketball technical (23.2%) and tactical (24.1%) sessions, and game or competition-based practices (11.6%). The training load intensity progressively increased, peaking in January and February (100%), and tapering in the final month (81.2%).

We planned strength training and basketball practice with one training session lasting 120 minutes. The content of the program was based on scientific principles, with the primary objective of evaluating the effects of training intensity on the athletes' physical development, muscle mass, and strength. Accordingly, training intensity was carefully planned, which is presented in Table 2.

Table 2. Distribution of training content, hours, and intensity across four months of the training program

Training content	Training months					Total hours planned	
	XI	XII	I	II	III	Total hours	Percentage
General training /hours/	2	8	10	8	6	32	14.3%
Special training /hours/	8	16	16	12	8	60	26.8%
Basketball technical training /hours/	6	14	12	10	8	52	23.2%
Basketball tactical training /hours/	2	10	12	14	16	54	24.1%
Game, competition /hours/	2	6	4	8	6	26	11.6%
Intensity capacity /hours/	20	54	54	52	44		
Load intensity /%/	**37%**	**100%**	**100%**	**96.2%**	**81.2%**	**224**	**100.0%**

This table shows the entire training program of 224 hours that was carried out for a duration of four months, broken down into training months and by category. Most hours were spent on special and technical skills training.

Vol. 64 No 02(254) 2025
DOI: - https://doi.org/10.5564/pmas.v65i02.4391

Table 3. Characteristics of basketball and strength training agenda of NUM "Falcons" female basketball team

Content	General strength training	Basketball drills
Training goal	Increase muscle strength, Improve load-bearing capacity, Change body structure (circumference increase)	Improve personal skills Ball handling, ownership, Shooting, pass, dribble, Rebounding, shot blocking, Footwork Defense, offense system position combinations
Initial part (10–15 min)	Stretching, Light running, Warm-up exercises.	Stretching, Light running, Warm up with ball.
Main part (90 min)	· Resistance pulling, · TRX + Planche, · Body weight, strength training exercises using small weights, · By muscle group: legs, arms, back, chest, · Each exercise 3 rounds, 10–12 times.	Perform basic basketball techniques using individual and combination tactics
Final part (10–15 min)	Cool down, stretching, muscle relaxation	Cool down with ball, stretching

Program content explanation:

The training program comprised combination of body weight strength training (Planche, TRX) and exercises using small weights (dumbbells, disks, barbells) to comprehensively improve athletes' balance, groups of large body muscles, musculoskeletal system and functional strength. For example,

- *TRX (Total Resistance Exercises): This form of exercise uses body weight as resistance, activates the muscles of the arms, shoulders, and back, and improves upper-body strength, stability, and flexibility [25].*
- Planche exercises: These exercises consist of static movements in which the entire body weight is supported by the arms. They place significant demands on the core muscles, shoulders, arms, lower back, and other muscle groups. Core muscle training plays a crucial role in enhancing basketball players' overall athletic and skill performance, particularly in strength, sprinting, jumping, balance, agility, shooting, dribbling, passing, rebounding, and footwork [19].
- *Benefits of using combination exercises:* The combination of TRX and Planche type exercises paired with body weight resistance and enriched with additional equipment more effectively develops core stability and functional strength. They facilitate growth heights in dynamic power, movement coordination and stability, which are essential in basketball [6].
- *Light weighted strength training exercises:* They develop muscle tone, neuromuscular control, movement quality and stamina. Mostly 15–20 reps using 5–20 kg dumbbells, disks, barbells and other small weight equipment. This increases muscle micro activation, coordination, outer and inner stability.

"Strength training using small weights prevents muscle overload, corrects movement structure and becomes the foundation for improving coordination and stability.

The body weight exercises are especially effective in improving core stability [6]. Training sessions using body weight and

Vol. 64 No 02(254) 2025
DOI: - https://doi.org/10.5564/pmas.v65i02.4391

small weights (3 rounds, 10 reps) were planned and implemented in various phases depending on basketball position characteristics, age, sex and muscle development level.

Table 4. Sample One-time Basketball training session plan

Coaching session № 9
Training goal: Improve footwork, speed,decision-making, correlation between offense and defense.
Training organization method: Explain, demonstrate, group talks
Training duration: 120 minutes

Training	Duration	Content	Examples	Explanation
Beginning	15 min	Warm-up	Lay-up line, Dynamic stretch	Prepare to participate in game right away
Main practice	25 min	Agility drills	T-Drill, Cone reaction, V-cut	Speed to change direction, footwork
	25 min	Ball-handling & passing	2-ball drill, Passing under pressure	Decision-making, pass accuracy
	25 min	Fast break + Defense	Break drills, Zone defense, Pick & Roll, Pick & Pop	Offense plot, defense system
	15 min	Game simulation	5x5 situation game	Position, tactics, cooperation
Ending	15 min	Stretching + team feedback	Breathing exercises, team conclusion	Relaxation, improve understanding

Table 5. Sample One-time Strength training session plan

Coaching session № 4
Training goal: Develop chest, back, shoulders, arms and abdominal muscles, improve movement stability, strength pass, balance.
Training organization method: Explain, demonstrate, group talks
Training duration: 120 minutes

Training	Duration	Content	Examples	Explanation
Beginning	15 min	General warm-up	Light running, stretching, activation of joints using bands	Prepare upper body
Main practice	20 min	Chest strength	Bench press, Incline push-up, Dumbbell fly	Weight resistance
	20 min	Back strength	Bent-over row, TRX row, Deadlift	Armpit, lats activated
	15 min	Arms and shoulders	Biceps curl, Triceps dips, Shoulder press	Isolation exercises
	15 min	Core strengthening	Plank variation, Hollow hold, Russian twist	Balance and strength
	20 min	Circuit (3 rounds)	Push-up, Pull-up, Medicine ball throw	General body fitness
Ending	10 min	Rehabilitation stretching	Foam roller, Shoulder & arm stretch	Reduce muscle stiffness
	5 min	Load evaluation + encouragement evaluation	1-2 min discussion with each athlete	Psychology, understanding

Vol. 64 No 02(254) 2025
DOI: - https://doi.org/10.5564/pmas.v65i02.4391

RESULTS AND DISCUSSION

This study was conducted on 13 players from the NUM "Falcons" basketball team. Thirteen indicators of general physical development were measured at baseline, 2-month, and 4-month intervals, and the results were categorized by playing position.

Changes in these indicators were evaluated using the SPSS software and Repeated Measures ANOVA.

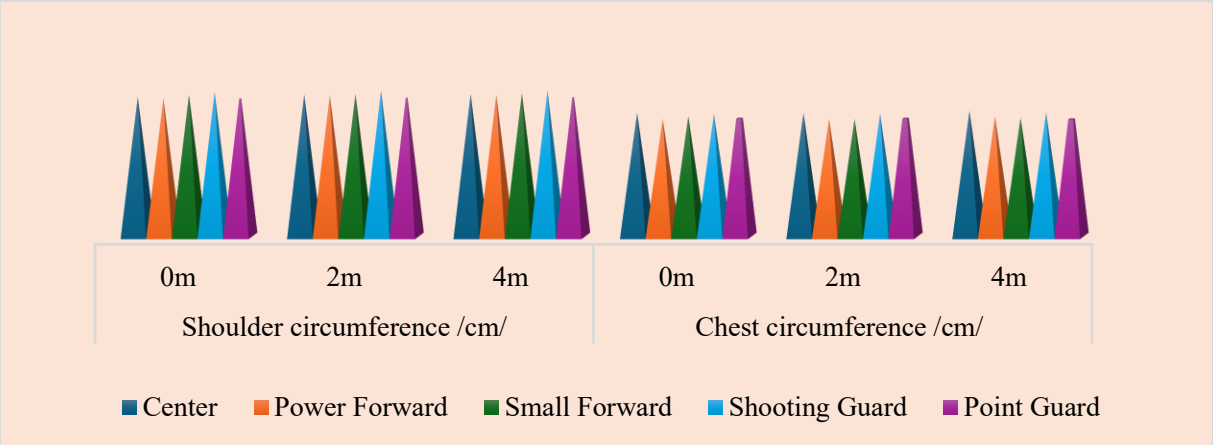

Figure 1. Comparison of shoulder and chest circumference measurements of NUM "Falcons" female basketball players.

A steady increase in the participants' shoulder circumference across 0, 2, and 4 months indicates upper-body muscle mass growth. Changes were most notable in Center and Power Forward positions, reflecting the effectiveness of targeted strength training.

The chest circumference showed progressive growth over the training period, with greater changes in Center and Power Forward positions compared to guards. This suggests that resistance training focusing on upper-body musculature was effective.

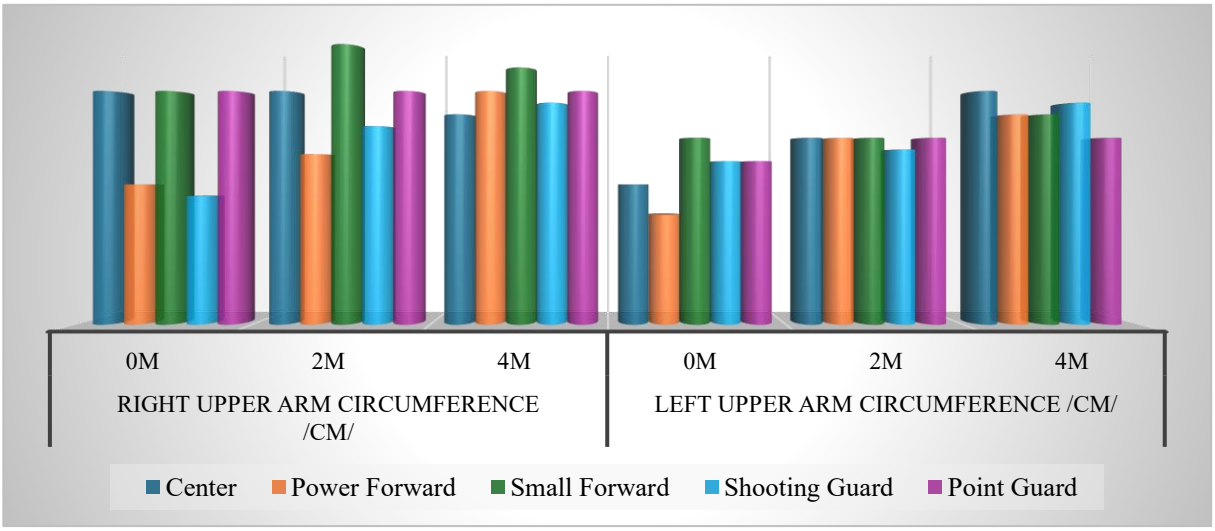

Figure 2. Comparison of right and left upper-arm circumference measurements of NUM "Falcons" female basketball players.

Vol. 64 No 02(254) 2025
DOI: - https://doi.org/10.5564/pmas.v65i02.4391

Guards (Point Guard and Shooting Guard) showed smaller increases compared to other positions, yet steady growth and improved muscle tone were evident. Repeated Measures ANOVA confirmed statistical significance ($p < .05$), demonstrating the effectiveness of the training program for upper-arm muscle development.

Progressive growth was recorded throughout the training period. Changes were more pronounced in Centers and Power Forwards compared to Guards, suggesting that upper-body resistance training contributed to enhanced muscle development.

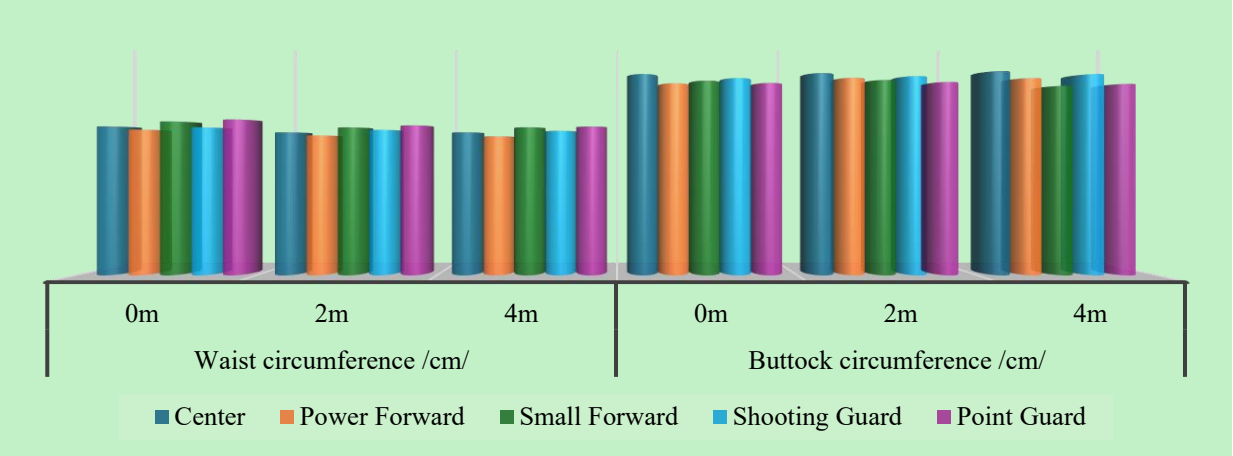

Figure 3. Comparison of waist and buttocks circumference measurements of NUM "Falcons" female basketball players over the training period.

The waist and buttocks circumference of the NUM "Falcons" female basketball players progressively increased over the four-month training period. This trend reflects the effectiveness of the strength training program that targeted the deep muscles of the abdominal cavity and pelvic floor. The observed changes suggest increased hypertrophy and activation of the gluteal and trunk-stabilizing muscles, which are key components of the core system. These muscle groups play a vital role in maintaining posture, ensuring balance, and supporting efficient movement control [17].

The findings are consistent with previous research demonstrating that targeted core and hip training can significantly increase muscle mass and strength in the waist and buttocks regions, while also enhancing the function of both the trunk and hip muscles [10, 18, 24, 26].

The results of our study confirm this trend. Improved endurance in the core muscles of the waist and abdomen leads to more effective transmission of lower-limb strength. Statistical analysis using Repeated Measures ANOVA confirmed that these changes were significant ($p<0.05$), supporting the effectiveness of the applied training approach in promoting lower-body muscular development.

Vol. 64 No 02(254) 2025
DOI: - https://doi.org/10.5564/pmas.v65i02.4391

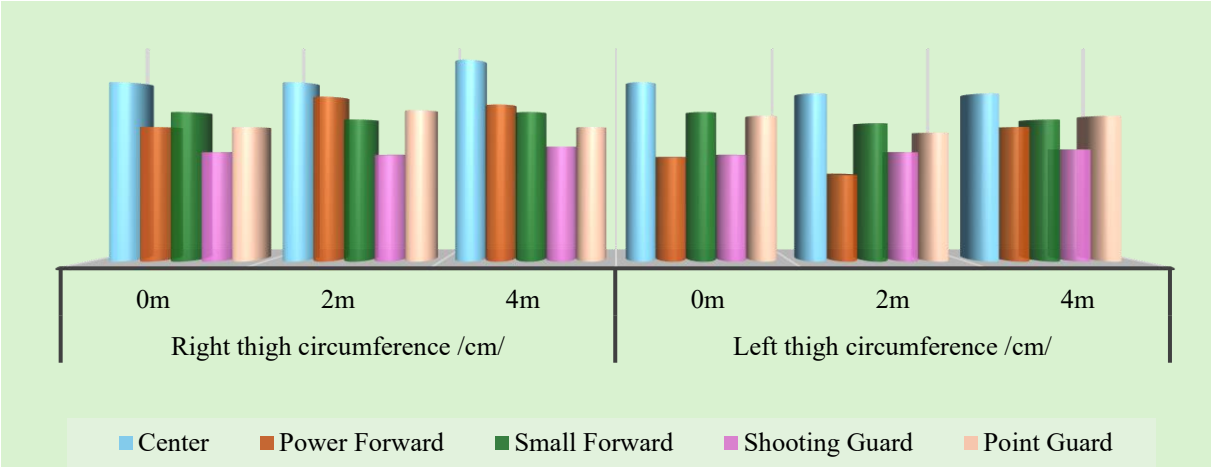

Figure 4. Comparative results of right and left thigh circumference measurements of the NUM "Falcons" female basketball players.

Based on the data presented in the figure, both right and left thigh circumferences showed a steady increase across all positions over the four-month period. This increase was more pronounced among athletes playing in the Center and Power Forward positions, which was likely due to greater demands placed on the lower body during jumping, rebounding, and post-play.

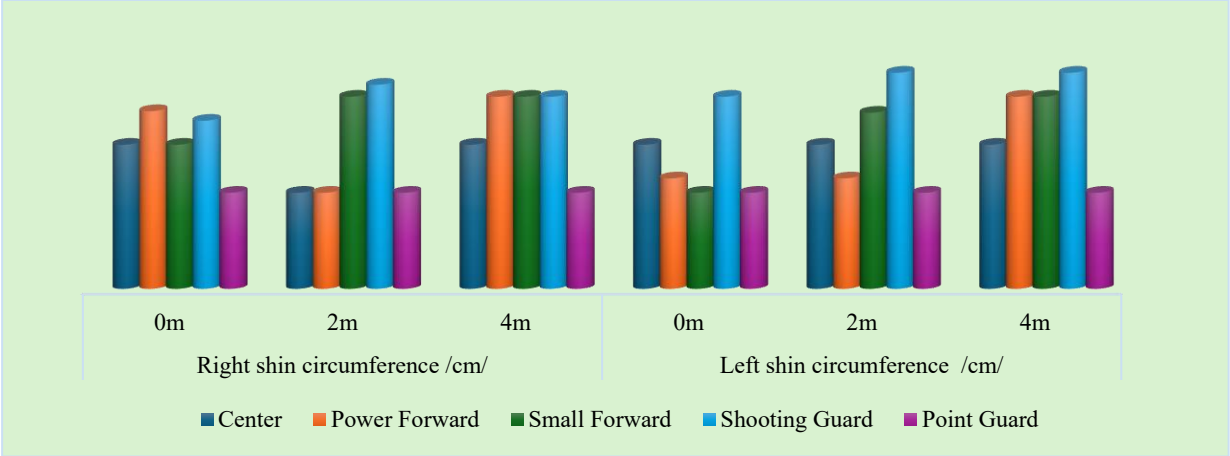

Figure 5. Comparative results of right and left shin circumference measurements of the NUM "Falcons" female basketball players.

Shin circumference changes on both sides were minimal across most positions, suggesting restricted development of the lower leg muscles. However, a slight increase was observed in the Center position group, which may reflect more intensive engagement of the calf muscles in vertical power movements. This aligns with previous findings that calf muscles, composed predominantly of type I slow-twitch fibers and continuously activated in daily movements, tend to develop more slowly and require higher training loads and volume to induce significant growth [1, 29].

Furthermore, strong core muscles play a vital role in stabilizing the trunk and efficiently transferring energy between the lower and upper limbs [27]. During dynamic movements, such as squatting and running, the core musculature functions to absorb, store, and redistribute force, thereby enhancing muscle control, improving coordination between limbs, optimizing energy expenditure, and contributing to better sprinting performance [30].

Vol. 64 No 02(254) 2025
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Table 6. Comparison of statistical indicators resulting from training to increase muscle mass and strength of NUM "Falcons" female basketbal players.

Variable	(Mean ± SD)			ANOVA Results by Variable					
	0 month	2 months	4 months	F (time)	η^2	p-value	p (time)	95% CI	Post-hoc
Body height	1.70±0.05	1.70±0.05	1.70±0.05	0.00	0.000	1.000	1.000	[1.71–1.71]	-
Body weight	65.1±4.3	65.1±4.6	65.2±4.1	5.41	0.295	0.014	0.014	[64.2–66.1]	0-4*
BMI	22.24±1.5	22.2±1.47	22.27±1.2	3.44	0.218	0.041	0.041	[23.6–23.9]	0-4*
Shoulder circumference /cm/	103.4 ±3.0	104.7 ±2.6	104.9±2.4	7.12	0.352	0.002	0.002	[90.5–92.4]	0-4*
Chest circumference /cm/	88.4 ± 3.6	88.0 ± 3.2	89.0 ± 3.6	6.85	0.341	0.003	0.003	[85.1–87.3]	0-4*
Right upper arm circumference /cm/	29.0±1.9	29.7±1.6	29.9 ±0.8	8.56	0.377	0.001	0.001	[25.2–27.1]	0-2*, 0-4*
Left upper arm circumference /cm/	28.4±1.2	28.9±0.9	29.6±1.3	8.33	0.371	0.001	0.001	[24.9–26.3]	0-2*, 0-4*
Waist circumference /cm/	76.2±4.9	73.7±4.3	73.4±3.7	0.52	0.042	0.611	0.611	[70.7–71.3]	-
Buttock circumference /cm/	99.2±2.85	100.1±2.6	99.7±2.85	14.94	0.861	0.002	0.002	[74.2–76.8]	0–4m: p < .01
Right thigh circumference /cm/	58.1±2.3	58.3±2.4	58.4±3.04	9.16	0.388	0.001	0.001	[55.8–58.1]	0-2*, 0-4*
Left thigh circumference /cm/	57.9±2.46	57.5±2.65	58.0±2.62	8.98	0.385	0.001	0.001	[55.4–57.6]	0-2*, 0-4*
Right calf circumference /cm/	36.61±1.4	36.57±1.6	36.76±1.5	0.32	0.028	0.732	0.732	[35.6–36.0]	-
Left calf circumference /cm/	36.38±1.1	36.69±1.3	36.84±1.3	2.08	0.153	0.161	0.161	[36.1–36.6]	-

Vol. 64 No 02(254) 2025
DOI: - https://doi.org/10.5564/pmas.v65i02.4391

According to statistical processing of the results, the strength training program implemented over a period of four months yielded positive results, as well as brought about statistically significant changes in the female players' muscle structure and measurements by many indicators. This was proven by the Repeated Measures ANOVA analysis. Moreover, athletes' physical development, muscle mass and strength have significantly increased categorized by five different basketball positions.

These results prove that the training program tailored to each position was effective. (Please see Attachment 1: Statistical changes by each position).

Based on the study results, we evaluated changes in the 13 body structure indicators over time using *Repeated Measures ANOVA* analysis in SPSS program. The following conclusions ensue:

1. Body weight and BMI:
   - Body weight (F=5.41, p=0.014) and BMI (F=3.44, p=0.041) indicators show statistically significant growth, which points to probable increase in muscle mass during the training.
   - Post-hoc analysis between 0–4 months proved there is statistical difference.
2. Upper body muscle circumference indicators:
   - Shoulders, chest, right and left upper arm circumferences have significantly increased (p<0.01), the highest impact was observed in left upper arm (F=8.23, η^2=0.371). Uniform development of muscle points to accurate planning of load.
3. Waist and buttocks circumference:
   - Buttocks circumference (F=10.42, p<0.001, η^2=0.449) shows significant impact increase.
   - Waist circumference (p=0.161) although shows statistically insignificant change, the decrease observed points to reduced fat and strengthened muscle.
4. Lower body indicators:
   - Thigh circumference indicators: right (F=3.82, p=0.030) and left (F=3.80, p=0.031) show increase.
   - Right shin circumference (F=4.42, p=0.021) shows a statistically significant change, whereas the left shin (p=0.161) showed no change. This is attributed to the probable cause of the athletes' asymmetric movement where one side of the body is capable of moving better than the other side.

CONCLUSIONS

The evolving dynamics of modern basketball, including increased pace, intensity, and tactical variability, have elevated the physical and technical demands placed on athletes. Consequently, players' physical development, individual skills, and performance quality have become critical determinants of success. Positional demands vary significantly, with frontcourt players requiring greater strength and body mass, while guards rely on speed, agility, and explosiveness.

Assessing players' anthropometric and physical characteristics is essential not only for evaluating current performance, but also for designing tailored training programs based on age, sex, and playing position.

Such assessments provide coaches with data-driven strategies and serve as a baseline for tracking long-term development.

The four-month strength training program implemented in this study resulted in statistically significant improvements in body structure, composition and muscle development among female basketball players. Notable gains were observed in the shoulders, upper arms, waist, buttocks, and thighs - large muscle groups that contribute to balance, endurance, strength, and aesthetics. A decrease in waist circumference and an increase in gluteal circumference suggest reductions in adipose tissue and improvements in muscle strength, aligning with expected physiological responses [7, 27].

Vol. 64 No 02(254) 2025
DOI: - https://doi.org/10.5564/pmas.v65i02.4391

Moreover, the observed anthropometric adaptations were also aligned with positional demands of the players. For example, forwards and centers benefited from enhanced upper and lower body mass contributing to physical dominance, whereas guards retained agility with minimal weight gain. This underlines the importance of tailoring strength training based on position-specific functional needs [32].

In conclusion, the study highlights the efficacy of position-specific strength training in enhancing female athletes' physical development and supports the need for individual, scientifically informed training interventions. Further longitudinal studies are recommended to explore training variables, physiological responses, and long-term adaptations in greater depth.

Furthermore, the observed variation in lower limb muscle development across player positions emphasizes the importance of designing training programs tailored to the functional and biomechanical demands of each playing role.

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The authors also extend their gratitude to colleagues who supported data processing and statistical analysis throughout the research process.

Ethical Approval

This study was conducted in accordance with relevant institutional guidelines and with the approval of the ethics committee. All student-athletes participated voluntarily and provided informed consent prior to inclusion in the study.

Author Contributions

The authors contributed actively to all stages of the study, including conceptualization, methodology development, data collection, statistical analysis, manuscript writing, and revisions. R. G. designed the training and research program and methodology for the NUM "Falcons" team, supervised the study, performed the data analysis, and wrote and revised the manuscript. L. E. contributed to the development of the basketball training program and assisted in the translation of the manuscript. Ts. S. developed and regularly implemented the strength training program for the NUM "Falcons" team, monitored changes in players' physical fitness, and conducted case interviews. All authors collaborated closely and approved the final version of the manuscript.

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Conflict of Interest

The authors declare that there is no conflict of interest.

Vol. 64 No 02(254) 2025
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Vol. 64 No 02(254) 2025
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Vol. 64 No 02(254) 2025
DOI: https://doi.org/10.5564/pmas.v63i01.2816

Appendix 1: Statistical changes by each position.

Variable	Pos	Mean ± SD (0m)	Mean ± SD (2m)	Mean ± SD (4m)	p-value	F (time)	p (time)	η²	95% CI	Post-hoc
Shoulder circumference /cm/	PG	101.0±1.9	101.5±1.6	102.0±1.4	.000	24.3	.752	-	-	NS
	SG	106.0±1.4	106.5±1.3	107.0±1.2	.184	2.0	.503	-	-	NS
	SF	104.0±1.5	104.6±1.4	105.2±1.3	.132	1.9	.486	-	-	NS
	PF	103.0±1.6	103.5±1.5	104.0±1.4	.048	3.9	.661	-	-	NS
	C	103.3±1.7	103.8±1.6	104.3±1.5	.304	1.4	.420	-	-	NS
Chest circumference /cm/	PG	95.0 ± 1.3	95.5 ± 1.2	95.8 ± 1.1	0.081	2.10	0.09	0.18	[94.2–96.9]	—
	SG	96.5 ± 1.0	97.0 ± 1.1	97.2 ± 1.0	0.058	2.45	0.07	0.22	[95.8–98.0]	—
	SF	98.0 ± 1.5	99.0 ± 1.3	99.5 ± 1.2	0.015	3.92	0.04	0.31	[97.2–100.1]	0–4: p=0.05
	PF	100.2 ± 1.2	101.8 ± 1.1	102.0 ± 1.0	0.002	4.87	0.02	0.38	[99.5–102.5]	0–4: p=0.04
	C	102.5 ± 0.7	104.5 ± 0.7	104.5 ± 0.7	<0.001	5.32	0.01	0.42	[101.1–103.9]	0–2: p=0.03
L_U_Arm /cm/	PG	28.5 ± 0.7	29.0 ± 0.0	29.5 ± 0.7	<0.01	4.90	0.02	0.51	[27.5–30.5]	0–4: p=0.02
	SG	28.5 ± 1.2	28.75 ± 1.3	29.75 ± 1.1	<0.05	3.90	0.04	0.44	[27.3–30.9]	0–4: p=0.03
	SF	29.0 ± 1.7	29.0 ± 1.7	29.5 ± 1.0	0.08	2.30	0.08	0.36	[27.1–31.6]	-
	PF	29.0 ± 0.0	29.0 ± 0.0	29.5 ± 2.1	0.20	1.80	0.20	0.28	[25.0–33.0]	-
	C	27.5 ± 0.5	29.0 ± 0.0	29.5 ± 0.7	0.03	5.10	0.03	0.52	[26.3–30.7]	0–4: p=0.04
R_U_A /cm/	PG	30.0 ± 1.4	30.0 ± 0.0	30.0 ± 0.0	0.84	0.18	0.84	0.02	[29.0–31.0]	-
	SG	27.75 ± 2.36	29.00 ± 2.58	29.75 ± 0.96	0.23	1.60	0.23	0.20	[25.9–31.6]	-
	SF	30.0 ± 1.0	30.5 ± 0.5	30.5 ± 0.5	0.30	1.33	0.30	0.18	[28.9–31.6]	-
	PF	28.0 ± 1.4	29.5 ± 0.7	29.5 ± 1.4	0.25	1.51	0.25	0.19	[26.4–30.6]	-
	C	30.0 ± 2.8	30.0 ± 2.8	29.5 ± 0.7	0.91	0.09	0.91	0.01	[26.4–33.6]	-
Waist circumference /cm/	PG	79.0±4.2	76.0±5.7	75.5±4.9	.000	14.94	.002	.651	69.1–84.5	p<.05
	SG	75.0±8.5	73.8±7.1	73.3±5.7	.184	2.0	.503		68.6–79.4	
	SF	78.0±0.0	75.0±0.0	75.0±1.0	.132	1.9	.486		69.0–82.9	
	PF	73.9±1.2	70.9±1.3	70.5±0.7	.048	3.9	.069		64.0–79.5	
	C	75.5±3.5	72.5±2.1	72.5±2.1	.304	1.4	.420		65.8–81.2	

Vol. 64 No 02(254) 2025
DOI: https://doi.org/10.5564/pmas.v63i01.2816

Buttocks circumference /cm/	PG	79.0±4.2	76.0±5.7	73.5±4.9	.002	14.94	.002	.861	69.13–84.54	0–4m: p<.01
	SG	75.0±8.5	73.8±5.2	73.3±5.2	.002	14.94	.002	.861	68.65–79.45	0–4m: p<.01
	SF	78.0±0.0	75.0±0.0	75.0±0.0	.002	14.94	.002	.861	69.40–82.90	0–4m: p<.01
	PF	70.9±1.3	72.5±2.1	72.5±2.1	.002	14.94	.002	.861	64.05–79.45	0–4m: p<.01
	C	75.5±2.1	73.8±3.9	73.5±3.9	.002	14.94	.002	.861	65.79–81.20	0–4m: p<.01
Right thigh circumference /cm/	PG	58.0 ± 1.14	58.8 ± 1.22	58.0 ± 1.45	—	0.399	0.675	—	—	
	SG	56.9 ± 1.14	56.8 ± 1.22	57.1 ± 1.45						
	SF	58.7 ± 1.14	58.3 ± 1.22	58.7 ± 1.45						
	PF	58.0 ± 1.14	59.4 ± 1.22	59.0 ± 1.45						
	C	60.0 ± 1.14	60.0 ± 1.22	61.0 ± 1.45						
Left thigh circumference /cm/	PG	58.5 ± 1.39	57.8 ± 1.36	58.5 ± 0.9	—	2.278	0.124	—	—	
	SG	56.8 ± 1.39	56.9 ± 1.36	57.0 ± 0.9						
	SF	58.7 ± 1.39	58.2 ± 1.36	58.3 ± 0.9						
	PF	56.7 ± 1.39	55.9 ± 1.36	58.0 ± 0.9						
	C	60.0 ± 1.39	59.5 ± 1.36	59.5 ± 0.9						
Right Shin Circumference /cm/	PG	38.25 ± 0.96	39.12 ± 0.25	39.12 ± 0.25		0.0	1.0	0.0	-	-
	SG	37.00 ± 0.00	36.00 ± 0.00	38.00 ± 0.00		0.268	0.768	0.067	[36.0–37.3]	
	SF	36.67 ± 0.58	37.00 ± 0.00	37.00 ± 0.00		0.0	1.0	0.0	-	
	PF	36.00 ± 0.00	36.00 ± 0.00	36.00 ± 0.00		1.0	0.422	0.333	[36.0–37.0]	
	C	36.50 ± 0.71	36.50 ± 0.71	36.50 ± 0.71		1.5	0.244	0.429	[36.0–36.5]	Increase observed, but not statistically significant (p > 0.05)

Vol. 64 No 02(254) 2025
DOI: https://doi.org/10.5564/pmas.v63i01.2816

Left Shin Circumference /cm/	PG	36.00 ± 0.00	36.00 ± 0.00	36.00 ± 0.00		0.000	1.000	0.000	[33.7–38.3]	No significant difference
	SG	37.75 ± 2.50	37.75 ± 2.50	37.75 ± 2.50		0.250	0.789	0.063	[35.5–38.8]	No significant difference
	SF	36.00 ± 0.00	36.33 ± 0.58	36.33 ± 0.58		0.750	0.492	0.158	[34.9–38.8]	Increase detected, but not statistically meaningful
	PF	36.00 ± 0.00	36.00 ± 0.00	38.00 ± 0.00		1.500	0.244	0.429	[34.0–38.6]	Increase observed, but not statistically significant ($p > 0.05$)
	C	36.50 ± 0.71	36.50 ± 0.71	36.50 ± 0.71		0.667	0.548	0.250	[34.1–38.8]	No statistically significant difference