UNIVERSITY OF BELGRADE

FACULTY OF SPORT AND PHYSICAL EDUCATION

Mazen Azzi

Associations Between Anthropometric Characteristics, Motor Abilities and Technical Skill Development in Lebanese Youth Basketball: A Cross-Positional Study

Doctoral Dissertation

Belgrade, 2026

УНИВЕРЗИТЕТ У БЕОГРАДУ

ФАКУЛТЕТ СПОРТА И ФИЗИЧКОГ ВАСПИТАЊА

Мазен Ази

Релације између антропометријских карактеристика, моторичких способности и развоја техничких вештина у либанској омладинској кошарци: студија пресека

Докторска дисертација

Београд, 2026

MENTOR:

Dr Saša Jakovljević, redovni profesor, Univerzitet u Beogradu – Fakultet sporta i fizičkog vaspitanja,

____

ČLANOVI KOMISIJE:

1. Dr Radivoj Mandić, vanredni profesor, Univerzitet u Beogradu – Fakultet sporta i fizičkog vaspitanja,

____

2. Dr Marija Macura, redovni profesor, Univerzitet u Beogradu – Fakultet sporta i fizičkog vaspitanja,

____

3. Dr Jelena Obradović, redovni profesor, Univerzitet u Novom Sadu – Fakultet sporta i fizičkog vaspitanja,

____

Datum odbrane:

____

MENTOR:

Dr. Saša Jakovljević, full professor, University of Belgrade - Faculty of Sports and Physical Education,

____

COMMITTEE MEMBERS:

1. Dr. Radivoj Mandić, associate professor, University of Belgrade - Faculty of Sports and Physical Education,

____

2. Dr. Marija Macura, full professor, University of Belgrade - Faculty of Sports and Physical Education,

____

3. Dr. Jelena Obradović, full professor, University of Novi Sad - Faculty of Sports and Physical Education,

____

Defense date:

____

ACKNOWLEDGMENTS

I would like to express my endless gratitude to my supervisor, Professor Jakovljevic, for his continuous support, guidance, and academic mentorship throughout my doctoral dissertation. His way of guiding every detail with expertise, his technical comments, and encouragement sharpened the direction and quality of this research. I am deeply thankful for all that he has already done for me, and it was all done with patience, kindness, and dedication.

I also extend my deep appreciation to the faculty members and all the staff of the University of Belgrade for all that they did during this long process. Academic and administrative support was on a very high level, and they played an important role in my successful work.

My gratitude also goes to all coaches, youth basketball players, and clubs who participated in this study. Without their participation, a big part of this dissertation would not have been possible.

I would also like to thank my colleagues and friends for their support, motivation, and help.

Last but not least, my family for their unconditional support and their belief in me throughout this long academic journey.

Associations Between Anthropometric Characteristics, Motor Abilities and Technical Skill Development in Lebanese Youth Basketball: A Cross-Positional Study

ABSTRACT

Introduction: Technical skills, motor abilities and anthropometry are important factors in the development of young basketball players. Anthropometric measures are very important for tests of skills and physical abilities. The interaction of these factors and differences in relation to game position have not been sufficiently examined.

Purpose: The purpose of this dissertation was to investigate the relationships among certain anthropometric characteristics and physical abilities, and to determine their impact on basketball skills among young Lebanese basketball players, by gender and playing position.

Methods: Bioelectrical impedance and standardized testing protocols were used to measure the body composition, motor abilities (vertical jump, T-drill, 20 m sprint), and basketball skills (shooting, dribbling, passing) in a sample of 260 players (160 males, 100 females; ages 16–18). Regression analysis and Pearson correlations were performed.

Results: The predictive efficiency of the anthropometric characteristics were limited unlike motor skills. Body fat percentage strongly predicted shooting ($p<.05$; $R^2 \approx .10$) and partially influenced dribbling ($R^2 \approx .14$), but not passing. Shooting was predicted by power and speed ($R^2 \approx .24$), while dribbling was predicted by agility, speed, and power ($R^2 \approx .38$). Power barely faintly predicted passing ($R^2 \approx .16$). Although gender attenuated these correlations, playing position had a greater impact on motor abilities than technical skills.

Conclusion: Technical performance depends on motor skills, particularly agility, speed, and explosive strength, while anthropometric considerations are minor. Training should balance physical conditioning with technical improvement, and talent assessment should consider gender and developmental stage.

Keywords: Adolescents, Technical Performance, Basketball, Sex Characteristics, Guard, Foreward, Center

Scientific Field: Physical education and sport

Scientific subfield: Physical education, sports and recreation sciences

UDC number: 796.323.012.1:796.323.015.1:572

Релације између антропометријских карактеристика, моторичких споосбности и развоја техничких вештина у либанској омладинској кошарци: студија пресека

РЕЗИМЕ

Увод: Техничке вештине, моторичке способности и антропометрија су важни фактори у развоју младих кошаркаша. Антропометријске мере су веома важне за тестове вештина и физичких способности. Интеракција ових фактора и разлике у односу на позицију у игри нису довољно испитане.

Циљ: Циљ ове дисертације је био да се испитају односи између одређених антропометријских карактеристика и физичких способности и да се утврди њихов утицај на кошаркашке вештине код младих либанских кошаркаша, по полу и позицији у игри.

Методе: Биоелектрична импеданса и стандардизовани протоколи тестирања су примењени за мерење телесног састава, моторичких способности (вертикални скок, Т-тренинг, спринт на 20 м) и кошаркашких вештина (шутирање, дриблинг, додавање) у узорку од 260 играча (160 мушкараца, 100 жена; узраста 16–18 година). Извршена је регресиона анализа и Пирсонове корелације.

Резултати: Предиктивна ефикасност антропометријских карактеристика била је ограничена, за разлику од моторичких вештина. Проценат телесне масти снажно је предвидео шутирање ($p<.05$; $R^2 \approx .10$) и делимично дриблинг ($R^2 \approx .14$), али не и додавање. Шутирање је предвиђено снагом и брзином ($R^2 \approx .24$), док је дриблинг предвиђен агилношћу, брзином и снагом ($R^2 \approx .38$). Снага је једва предвидела додавање ($R^2 \approx .16$). Иако је пол ослабио ове корелације, позиција у игри имала је већи утицај на моторичке способности него на техничке вештине.

Закључак: Техничке перформансе зависе од моторичких вештина, посебно агилности, брзине и експлозивне снаге, док је утицај антропометрије мали. Тренинг треба да уравнотежи физичку кондицију са техничким побољшањем, а процена талента треба да узме у обзир пол и развојну фазу.

Кључне речи: адолесценти, техничке перформансе, кошарка, полне карактеристике, бек, крило, центар

Научна област: Физичко васпитање и спорт

Ужа научна област: Физичко васпитање, спорт и рекреација

УДК број: 796.323.012.1:796.323.015.1:572

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS

WHO – World Health Organization

PA – Physical Activity

BMI – Body Mass Index

FM – Fat Mass

FFM – Fat-Free Mass

PBF – Percent of Body Fat

PSMM – Percent of Skeletal Muscle Mass

PBFM – Percent of Body Fat Mass

SMMI - Skeletal Muscle Mass Index

CSA- Muscle Cross-Sectional Area

BFM – Body Fat Mass

PFI – Protein Fat Index

SMM – Skeletal Muscle Mass

MFI- Muscle-Fat Index

PM – Protein Mass

BFMI – Body Fat Mass Index

BM – Body Mass

BH – Body Height

DXA – Dual-Energy X-Ray Absorptiometry

BIA – Bioelectrical Impedance Analysis

F.L. – Force Length

F.T. – Force Time

F.V.- Force Velocity

Vo^2max: Maximum Volume of Oxygen

HIIT - high-intensity interval training

NBA- National Basketball Association

SS -Speed Spot Shooting

CD- Control Dribble

PS- Passing Score

LU – Lebanese University

SD – Standard Deviation

Min – Minimum

Max – Maximum

cV% – The Coefficient of Variation

ANOVA – Univariate Analyses of Variance

MANOVA- Multivariate Analyses of Variance

L.O.C. – Levels of Confidence

MRA – Multiple Regression Analysis

KST- Kolmogorov-Smirnov test for distribution homogeneity

SPSS – Statistical Package for the Social Sciences

1 CHAPTER ONE: INTRODUCTION

1.1 Introduction

Both adults and children around the world enjoy playing basketball as a team sport. Basketball has advanced considerably over the past few decades, and the proportion of teenagers playing the sport has noticeably increased (Sodaitis, 2020). Selecting the most talented players is necessary given the large number of young basketball players (Masanovic, 2018). Thankfully, there is increasing interest in assessing athletes' performance, recognizing their strengths and shortcomings, assigning players positions, and identifying talent beyond coaches and physio managers (Masanovic, 2018). However, rather than researching talented athletes identified by tests, the scientific community has been more interested in examining the developmental paths to expert performance (Falk et al., 2004).

According to Trninic and Dizdar (2000), basketball is a highly dynamic and spontaneous sport that requires a blend of individual technical ability, physical fitness, team-oriented tactical knowledge, and motivational factors. Multidirectional movements and brief bursts of high-intensity activities, including sprinting, shuffling, jumping, and quick direction changes, are among the game's physical demands (Crisafulli et al., 2002). According to Cronin et al. (2003), coaches are therefore encouraged to focus on short, intense exercises (speed and agility) and assessments such as the vertical jump, agility T-test, sprints over extremely short distances (5 or 10 m), etc.

Because basketball involves so many unusual game situations that require frequent, quick changes of direction on the relatively small court, agility is very important. Basketball practice must therefore include agility drills that prioritize technique, strength, and sprint conditioning, as well as the improvement of perception and decision-making skills (Jakovljević et al., 2011).

Physical factors (strength, speed, muscle power, body height), alongside psychological aspects (self-confidence, self-determination, calmness), as well as technical and tactical skills, are all crucial components of a basketball player's profile. Basketball players' movement efficiency both with and without the ball, as well as in technical and tactical aspects of the game, is greatly influenced by their cognitive abilities, such as tactical thinking, alongside physical abilities like power, speed, and change of direction speed (Balciunas et al., 2006; Ben Abdelkrim et al., 2007). Although body height is genetically determined, players' physical ability to meet the demands of a basketball game can be evaluated using power, speed, and change-of-direction speed, all of which are influenced by training adaptation (Ben Abdelkrim et al., 2007; Bompa, 2000). Both the selection and training assessment processes benefit from this.

According to earlier studies, elite athletes exhibit high levels of speed, agility, and power, which are important performance indicators (Hoare, 2000). There is still much to learn about the relationship between these physical characteristics and basketball-specific abilities, especially among young athletes undergoing developmental transitions (Le Gall et al., 2010).

Basketball has changed a lot in the last several years, especially due to new rules that have sped up games and increased the need for both anaerobic and aerobic fitness (Ostojic et al., 2006). Examining how anthropometric and physical characteristics affect player success across different positions is crucial as the game becomes increasingly physically taxing. Because of their different physical and technical requirements, guards, forwards, and centers require different training plans (Winter et al., 2006). Knowing how these elements interact can help create customized training plans that align with job specifications and personal development paths.

Talented players can be distinguished from their peers based on anthropometric and physical traits (Jakovljević et al., 2011). High basketball performance has been linked to attributes like body height, body weight, arm span, quickness, and jumping ability (Hoare, 2000; Le Gall et al., 2010). Physical and anthropometric traits have been shown to predict young players' success (Le Gall et al., 2010) and aid in identifying gifted athletes (Hoare, 2000). It has been determined that a variety of physical attributes, including speed, agility, and jumping height, as well as anthropometric traits such as body height, body weight, and arm span, can be used to differentiate top players from others (Vila et al., 2012; Hoare, 2000).

The relationship between certain basketball technical field tests and specific anthropometric parameters suggests that some anthropometric measurements may have a moderately negative impact on technical skill performance in 14-year-old players (Karalejic et al., 2011). Furthermore, findings from three regression analyses indicate a moderate yet significant influence of anthropometric variables on sprint test results in 14-year-old basketball players (Jakovljevic et al., 2011). However, despite these findings, it remains unclear how these physical characteristics influence the development of basketball-specific skills such as shooting, dribbling, and passing in young players aged 16 to 18 years, especially in different contexts. Moreover, further research is needed to determine whether these anthropometric characteristics can be integrated into predictive models to assess game-related performance in young athletes (Sodaitis, 2020).

Speed and agility are among the least commonly evaluated qualities in basketball research, according to a comprehensive analysis of earlier studies (Ivanović et al., 2022). There is little empirical data linking these physical characteristics to basketball-specific abilities such as ball handling and shooting accuracy, despite their importance to game performance. A study analyzed the basic motor skills (20 variables) and basketball skills (4 variables) of high-quality 13 and 14-year-old basketball players and examined their correlations. The findings suggest a strong relationship between motor and basketball skills, with explosive power, speed, and agility playing a key role in performance. Dribbling, defensive movement, and passing were the most influential basketball skills. The study identified significant connections, with the first two established roots being the most important (Karalejić et al., 2011).

Additionally, the T-test and triple jump from a standing position showed a strong correlation with basketball skills, making them useful for assessing agility and explosive power in young players. These insights could help compare and evaluate talent in players of the same age group (Karalejic et al., 2011). Furthermore, whereas many studies have examined how biological maturation affects the performance of teenage athletes (Rinaldo et al., 2020), fewer have examined preadolescent athletes and the complex relationships among physical attributes, technical skill, and anthropometric features. The assessment of young athletes is made more difficult by growth-related developmental variations, underscoring the need for thorough evaluation methods.

Numerous team sports, such as American football, soccer, rugby, and volleyball, have consistently demonstrated the importance of physical and anthropometric traits in talent selection (Hoare, 2000; Ostojic et al., 2006). These studies have repeatedly shown that a mix of technical abilities and physical characteristics influences athletic success. More precisely, studies on basketball have shown that up to 40% of the variation in playing performance can be explained by fitness test results (Hoare, 2000). However, insufficient research has been conducted to determine the extent of these interactions, especially in Lebanese youth basketball.

In the Lebanese context, basketball has been the most successful sport at an international level, with the national team qualifying for the World Championship four times (Nassif & Amara, 2018). The country's professional league, which features National Basketball Association (NBA) players, has contributed to the sport's growing popularity. However, despite basketball's prominence, youth player development programs lack a systematic approach to assessing physical and technical skills based on playing position. There remains a significant knowledge gap regarding how different anthropometric and physical attributes influence skill development and performance in young Lebanese basketball players.

2 CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Anthropometric and physical fitness characteristics are crucial for the development of technical skills and positional difference in youth basketball, according to the reviewed research. Even if there are recurring patterns that favor athletes who are taller, more explosive, and better coordinated, inclusive, integrative, and culturally diverse research is still desperately needed. This chapter will advance theoretical knowledge and practical approaches in talent development by offering fresh perspectives on this theme.

2.2 Motor Learning and the Intergrative Model of Sports Performance in Basketball

Basketball skill acquisition is widely recognized as a complex process grounded in the principles of motor learning, which describe how athletes develop, refine, and automate movement patterns through repeated practice and experience. Motor learning theory emphasizes the interaction between cognitive processing, perceptual awareness, and motor execution in the acquisition of sport-specific skills. In basketball, this interaction is particularly evident in the acquisition of fundamental techniques such as dribbling, shooting, passing, and defensive movements, all of which require coordinated neuromuscular control, perceptual decision-making, and continuous environmental feedback.

Within this theoretical perspective, the development of basketball performance cannot be understood solely in terms of isolated physical or technical attributes. Rather, performance emerges from the interaction of multiple domains that collectively influence athletic effectiveness. This view aligns with the Integrative Model of Sports Performance, which proposes that successful performance results from the dynamic interaction of four key components: physical, technical, tactical, and psychological factors (Williams & Reilly, 2000). According to this model, athletes must possess not only the physical capacities required for sport performance such as strength, speed, and agility but also the technical proficiency to execute sport-specific skills, the tactical understanding to make effective decisions during play, and the psychological attributes necessary to perform consistently under competitive pressure.

In basketball, these components operate simultaneously during gameplay. For example, executing an accurate jump shot requires appropriate biomechanical technique, sufficient explosive power, perceptual awareness of defenders and teammates, and psychological control to maintain accuracy under time constraints. Similarly, effective dribbling demands rapid decision-making, spatial awareness, and precise motor coordination, often under dynamic, unpredictable conditions. The integrative model, therefore, highlights that technical skills cannot be separated from the physical and cognitive processes that support their execution.

Motor learning theory further explains how athletes gradually develop these complex performance capabilities. One of the most widely recognized frameworks describing skill acquisition is Fitts and Posner's three-stage model, which outlines the progression of learning through cognitive, associative, and autonomous stages (Magill & Anderson, 2010). During the cognitive stage, athletes focus on understanding the fundamental mechanics of a skill, often requiring conscious attention and frequent feedback. In the associative stage, movement patterns become more refined as errors decrease and coordination improves through continued practice. Finally, in the autonomous stage, the skill becomes automatic, allowing the athlete to perform efficiently while simultaneously processing tactical and environmental information during competition.

The application of motor learning principles in basketball training has been supported by empirical research. For instance, Gaggioli et al. (2013) demonstrated that combining mental training techniques with physical practice significantly enhanced the learning of complex basketball skills. Their findings suggest that cognitive strategies, such as imagery and attentional focus, can facilitate motor learning by improving movement planning and execution. Similarly, Benjaminse et al. (2017) emphasized the importance of motor learning strategies in basketball training, particularly for movement control and injury prevention. Their study highlighted how task-oriented learning environments and feedback mechanisms can improve both skill performance and movement efficiency among basketball players.

In addition, instructional approaches used in coaching can influence how effectively players acquire basketball skills. Nugroho et al. (2019) investigated the impact of different teaching models on basketball learning outcomes and found that training approaches aligned with motor learning principles significantly improved players' technical performance. Their findings suggest that the effectiveness of skill acquisition depends not only on the quantity of practice but also on the quality of instructional methods and the learner's existing motor skill level. This reinforces the importance of adopting evidence-based coaching strategies that support the progressive development of technical proficiency.

A key implication of motor learning theory for basketball training is the importance of creating representative learning environments that closely replicate the perceptual and decision-making demands of real game situations. Training tasks that simulate the dynamic conditions of competition such as variable defensive pressure, time constraints, and decision-making challenges can enhance the transfer of learned skills to actual gameplay. Furthermore, incorporating variability in practice conditions can promote adaptability, enabling players to apply learned techniques effectively in unpredictable situations (Davids et al., 2008).

Another important aspect of motor learning involves the role of feedback and deliberate practice in facilitating skill development. Both intrinsic feedback (information from the athlete's own sensory system) and extrinsic feedback (guidance from coaches or technology) contribute to refining movement patterns and correcting errors during training (Schmidt, & Lee, 2025). Deliberate practice, characterized by structured, goal-oriented training with continuous feedback, has been identified as a critical factor in the long-term development of athletic expertise (Ericsson et al., 1993).

Moreover, motor learning emphasizes the need for individualized training approaches that take into account an athlete's physical characteristics, learning style, and stage of skill development. Players differ in their anthropometric profiles, physical capacities, and prior experience, all of which can influence how quickly and effectively they acquire basketball skills. Tailoring training programs to these individual characteristics can accelerate learning, enhance motivation, and improve long-term performance outcomes.

In summary, motor learning theory and the Integrative Model of Sports Performance provide complementary frameworks for understanding the development of basketball skills. While motor learning explains the processes by which athletes acquire and refine movement patterns, the integrative model highlights the broader interactions among physical, technical, tactical, and psychological factors that influence overall performance. Together, these perspectives emphasize that effective basketball training should adopt a holistic approach, integrating physical conditioning, technical instruction, cognitive development, and psychological preparation. Such an approach not only facilitates skill mastery but also prepares athletes to perform effectively in the complex, dynamic environment of competitive basketball.

2.3 Body Composition

2.3.1 Conceptualizing Body Composition

The proportionate distribution of various tissues and substances within the human body is referred to as body composition. Usually, it can be divided into two main parts: fat mass (FM) and fat-free mass (FFM). All adipose tissue is included in fat mass, whereas all non-fat components, such as skeletal muscle, bone, water, and organ tissue, are included in fat-free mass. Skeletal muscle is the main source of FFM. To assess physical condition and performance potential, this categorization is frequently used in exercise science, sports nutrition, and health research (InBody, 2018).

2.3.2 Key Components of Body Composition

A. Skeletal Muscle Mass (SMM)

Movement, metabolic control, and general bodily function are all significantly influenced by skeletal muscle. It makes up the majority of FFM and accounts for about 32% of female body mass and 40% of male body mass (Janssen et al., 2004; Alvar et al., 2017). These muscles' distinct anatomical and functional characteristics contractility, excitability, extensibility, and elasticity are what allow them to produce force and movement (Stanković et al., 2022). Skeletal muscle is crucial for performance and physical adaptation since it is the sole metabolically active tissue among the components of body composition (Alvar et al., 2017).

B. Body Fat and Lipid Structure

Numerous vital physiological functions, including energy storage, thermoregulation, organ protection, and hormone balancing, are performed by body fat. It belongs to the larger class of lipids, which also includes essential and non-essential fats, and is biochemically constituted of triglyceride molecules, which are composed of three fatty acids and glycerol (Nikolaidis & Vassilios Karydis, 2011; Wang et al., 1992). Despite its vital roles, having too much body fat especially stored or non-essential fat raises the risk of diabetes, cardiovascular disease, and death (Charles et al., 2008; Stevens et al., 1998). It's crucial to maintain a healthy fat percentage; readings below 4% are thought to be harmful to long-term health (InBody, 2018).

Researchers have created a variety of body composition indices, including the Body Fat Mass Index (BFMI), Skeletal Muscle Mass Index (SMMI), and Muscle-Fat Index (MFI), to better understand and track fat-related health and performance consequences. To provide more reliable assessments, these methods take into consideration individual differences in sex, age, and body size (de Oliveira et al., 2016; Kukić & Dopsaj, 2017).

2.3.3 Anthropometric and Body Composition Profiles: Foundations for Performance and Talent Identification in Basketball

Anthropometric characteristics and body composition are fundamental determinants of basketball performance, forming the structural and physiological basis for movement efficiency, skill execution, and position-specific roles. Measurable attributes such as height, limb length, arm span, body mass, and the distribution of lean and fat tissue influence both mechanical and metabolic aspects of performance. These characteristics affect immediate athletic capabilities and play a significant role in long-term player development, individualized training design, and systematic talent identification throughout various stages of athletic progression (Lago-Peñas et al., 2011)

Body composition, defined as the relative proportions of lean and fat mass, directly influences key physical capacities in basketball, including strength, power, speed, agility, and endurance. A favorable body composition, characterized by higher lean muscle mass and lower non-functional fat mass, enhances force production, movement efficiency, and metabolic performance (Alejandro et al., 2015; Wilmore et al., 2004). These physiological advantages contribute to improved explosive performance in sprinting, jumping, rebounding, and rapid directional changes. Research indicates that increased lower-body muscularity significantly improves vertical jump performance and sprint acceleration, while lower adiposity supports greater agility and reduces fatigue during high-intensity play (Nikolaidis et al., 2014). Additionally, the strength-to-weight ratio is critical in sports requiring frequent explosive movements, as a higher proportion of functional muscle mass relative to total body weight enables athletes to generate greater power during dynamic actions such as rebounding, shot blocking, and rapid transitions (Ziv & Lidor, 2009). Morphological dimensions such as height, arm span, and limb length are also decisive for basketball-specific performance. These structural characteristics influence biomechanical leverage and spatial reach, which are essential in many aspects of the game. Taller players with longer limbs often have advantages in shooting over defenders, contesting shots, rebounding, and protecting the basket, making such attributes particularly valuable for frontcourt positions such as centers and forwards (Hoare, 2000). Conversely, players occupying perimeter positions typically benefit from relatively lighter body structures and lower fat percentages, which facilitate greater mobility, speed, and coordination when performing tasks such as dribbling, rapid changes of direction, and defensive coverage (Carvalho et al., 2018).

Recent research underscores the importance of anthropometric characteristics in differentiating competitive levels within basketball populations (Alejandro et al., 2015). For instance, Torres-Unda et al. (2013) found that elite adolescent basketball players exhibit superior anthropometric and maturational profiles compared to non-elite counterparts, particularly in stature and physical development. Similarly, a systematic review and meta-analysis by Han et al. (2023) identified anthropometric attributes, especially height, body mass, and limb dimensions, as key predictors in basketball talent identification models. These findings reinforce that structural characteristics contribute significantly to performance potential and competitive success.

Recent studies on youth athlete development have emphasized the value of anthropometric profiling in guiding talent selection and long-term development pathways. Bartlett and Murray (2025) examined the anthropometric and physical characteristics of highly trained youth basketball players and concluded that body size and physical development are important considerations in talent selection. However, their findings also highlight the need to evaluate these characteristics alongside functional performance measures to achieve a comprehensive understanding of athletic potential. Similarly, Susanto et al. (2024) proposed an integrated talent identification model for young basketball players that combines anthropometric measures with biomotor, technical, and tactical assessments, underscoring the multidimensional nature of athletic development. and performance-monitoring programs, anthropometric and body-composition assessments can provide valuable information for coaches and sports scientists. Such evaluations enable practitioners to design individualized conditioning and nutritional strategies tailored to each athlete's specific physical characteristics and developmental needs. For instance, players with higher body fat may benefit from targeted metabolic conditioning and dietary interventions to improve body composition. In contrast, athletes seeking to enhance explosive performance may focus on resistance and plyometric training to increase lean muscle mass and neuromuscular efficiency. Through these individualized approaches, training programs can optimize both performance outcomes and long-term athlete health.

Anthropometric monitoring is especially valuable in youth basketball, where biological growth and maturation significantly influence performance trajectories. Tracking changes in body size, limb length, and body composition during adolescence can help identify early maturers and athletes with long-term developmental potential, even if they do not yet exhibit superior performance characteristics. Recognizing these growth patterns enables coaches and talent scouts to make more informed decisions regarding athlete selection and development, reducing the risk of excluding promising players based solely on temporary physical disadvantages.

While anthropometric characteristics are useful indicators of potential performance, relying solely on structural attributes can lead to biased talent identification practices. Contemporary talent development literature emphasizes that physical characteristics should be evaluated alongside technical skills, tactical awareness, psychological readiness, and physical performance capacities to ensure a balanced and equitable assessment of athletic potential (Vila et al., 2012; Han et al., 2023; Susanto et al., 2024). This multidimensional perspective aligns with modern athlete development frameworks, which recognize that long-term success in basketball depends on the interaction of structural, functional, technical, and cognitive factors.

In summary, anthropometric characteristics and body composition are essential components of basketball performance analysis and talent development. These physical attributes influence movement efficiency, biomechanical advantage, and role specialization, and provide valuable information for training design and athlete monitoring. When integrated with broader performance assessments, anthropometric profiling serves as a critical tool for optimizing player development, supporting evidence-based talent identification, and enhancing both current performance and long-term athletic progression in basketball.

There are a number of ways to measure body composition, and each has its own pros and cons. Skinfold measures and bioelectrical impedance analysis (BIA) are often employed field techniques due to their non-invasive nature and cost-effectiveness, although their precision is influenced by variables such as the examiner's proficiency, hydration level, and testing environment (Ceniccola et al., 2019). Dual-energy X-ray absorptiometry (DEXA), hydrostatic weighing, and air displacement plethysmography (BodPod) are more accurate ways to measure fat mass and lean tissue, but they need special equipment and aren't as easy to use for regular tests (Ackland et al., 2012).

2.4 Physical Abilities in Basketball

Basketball requires quick, multidirectional motions, explosive actions, and prolonged physical exertion, hence physical prowess is crucial to performance. Speed, agility, muscular strength, power, endurance, balance, coordination, and flexibility are important physical characteristics. For players to react quickly to shifting game circumstances, speed and agility are essential for swift offensive and defensive transitions (Scanlan et al., 2012). Jumping, running, and contact-heavy plays like driving to the basket or grabbing rebounds are all supported by muscular strength and power (Stojanović et al., 2018). Athletes can sustain performance for the duration of the game thanks to their aerobic and anaerobic endurance, particularly when they are fatigued (Ben Abdelkrim et al., 2007). Flexibility promotes joint mobility and injury prevention, whereas balance and coordination facilitate the execution of technical skills and movement efficiency (Ziv & Lidor, 2009).

It is essential to identify and improve these physical attributes through focused training in order to maximize player development, boost output, and reduce the chance of injury. Furthermore, the significance of customized training methods in basketball situations is underscored by the variations in physical demands among playing positions (Ostojic et al., 2006).

2.4.1 Muscular Strength and Force Production

A. Definition and Mechanisms

Muscular strength is broadly defined as the ability of a muscle or muscle group to exert force to overcome resistance. It can be evaluated under static (isometric), dynamic (concentric and eccentric), or isokinetic conditions (Pescatello, 2014). This capacity is underpinned by biomechanical and physiological factors, particularly the muscle's intrinsic contractile properties and its interaction with neural drive.

A.1. Mechanistic Relationships

- **Force-Length (F-L):** The Force-Length (F-L) is the optimal length of a sarcomere, where actin and myosin filaments overlap to generate maximum tension. Force decreases with muscle overstretching (Gordon et al., 1966).
- **Force-Time (F-T):** Longer force production times increase muscle force. The notion states that slow and explosive movements behave differently (Nigg et al., 2000)
- **Force-Velocity (F-V):** The relationship between force and velocity in concentric actions is inverse (F-V). Muscle force decreases with contraction speed and vice versa. Eccentric contractions increase force with velocity up to a point (Nigg et al., 2000).

A.2. Neural and Structural Factors

Force production goes beyond muscle size. Neurological and architectural variables also affect strength.

A.3. Brain Contributions

- **Motor Unit Recruitment:** Improved recruitment and synchronization of motor units contribute to initial training strength improvements (Enoka, 1997).
- **Firing Frequency:** Increased firing frequency improves tetanic contractions and force output (Nikolaidis et al., 2014).
- **Intermuscular Coordination**: Activating agonists and inhibiting antagonists enhances movement efficiency (Behm & Sale, 1993).

A.4. Structure

- **Muscle Cross-Sectional Area (CSA**): Hypertrophy increases parallel sarcomeres, boosting force production capacity (Zatsiorsky et al., 2020).
- **Muscle Architecture:** Pinnation angle, fiber length, and thickness affect force output (Lieber & Fridén, 2000).
- **Fiber Type Distribution**: Type II (fast-twitch) fibers increase force and power, whereas Type I (slow-twitch) fibers enhance endurance. Limited fiber type composition change can result from training (Staron et al., 1991).

2.4.2 Muscular Endurance

A. Definition and Types

Muscular endurance is the ability to perform submaximal muscle contractions over time, resisting fatigue. It is typically assessed through repetitive dynamic movements or sustained isometric contractions (Pescatello, 2014).

A.1. Types of Muscular Endurance:

- **Absolute Endurance:** The total number of repetitions performed at a given load, irrespective of individual maximum capacity. It is useful for comparing population-wide standards.
- **Relative Endurance:** Performance is measured using a percentage of the individual's one-repetition maximum (1-RM), thus allowing comparisons across different strength levels (Zatsiorsky et al., 2020).

These distinctions are especially relevant in performance testing, rehabilitation, and training program design.

A.2. Occupational Relevance

Muscular endurance plays a vital role in occupational settings that demand sustained physical output, particularly in tactical populations (e.g., law enforcement, military, firefighting).

- **Field-Related Testing:** Tasks such as push-ups, sit-ups, and loaded carries are standardized in many physical readiness assessments (Pihlainen et al., 2018).
- **Performance Prediction:** Studies have shown strong correlations between muscular endurance scores and occupational task performance (Dawes et al., 2016).

- **Injury Prevention:** Adequate endurance reduces musculoskeletal fatigue and the risk of overuse injuries in high-demand professions (Anderson & Plecas, 2000).

Moreover, endurance training enhances work capacity and task efficiency, making it essential in physical readiness programs

2.4.3 Strength, Speed, and Agility in Basketball

Strength, speed, and agility are widely recognized as three of the most fundamental physical attributes influencing basketball performance. The sport is characterized by intermittent, high-intensity actions such as sprinting, jumping, cutting, and rapid directional changes, all of which require the integrated functioning of these physical qualities. The dynamic interaction between strength, speed, and agility supports both offensive and defensive tasks, including executing fast breaks, performing explosive jumps for rebounds and blocks, evading defenders, and sustaining physical contact during gameplay. Athletes who develop these physical capacities generally demonstrate improved performance outcomes, greater resistance to fatigue and injury, and enhanced positional effectiveness on the court. Research consistently demonstrates that basketball performance depends on the ability to generate force rapidly and apply it efficiently during explosive movements (Ziv & Lidor, 2009). The physiological and biomechanical demands of basketball require players to perform repeated short bursts of high-intensity actions interspersed with lower-intensity activity. Consequently, effective training programs target the simultaneous development of muscular strength, sprint speed, and multidirectional agility to optimize performance (Delextrat & Cohen, 2009; Jakovljevic et al., 2012). The relative importance of these attributes varies by positional role, playing level, and athlete maturation, underscoring the need for individualized, position-specific conditioning strategies. Studies of youth and elite basketball players indicate that improvements in strength, speed, and agility are strongly associated with enhanced technical skill execution, such as dribbling efficiency, defensive movement, and shooting stability (Ziv & Lidor, 2009; Delextrat & Cohen, 2009; Erčulj et al., 2010). As a result, coaches and sport scientists increasingly implement integrated training models that combine resistance training, sprint development, and agility-based drills to reflect the complex movement patterns required in competitive basketball (Stanković & Цанкова-Калоянова, 2018).

A. Strength

Muscular strength is a critical physical component for basketball players, with lower-body and core strength underpinning many explosive and high-force movements during games. Lower-body strength directly contributes to jumping performance, sprint acceleration, and stability during rapid directional changes. Upper-body strength, by contrast, facilitates effective passing, shooting stability, ball control under defensive pressure, and physical resilience during contact situations such as driving to the basket or competing for rebounds (McGill et al., 2012).

Multiple studies have demonstrated a strong relationship between muscular strength and basketball-specific performance indicators. Greater lower-body strength is associated with increased vertical jump height, improved sprint performance, and enhanced ability to maintain positional dominance against opponents (Ziv & Lidor, 2009; McInnes et al., 1995). Core strength is also vital for trunk stabilization and efficient force transfer between the lower and upper body during explosive actions, which improves movement efficiency and reduces injury risk (McGill et al., 2012; Willardson, 2007).

Evidence from youth basketball populations suggests that early development of strength-related abilities contributes to improved speed–strength capacities and overall athletic performance. For instance, research on 10–11-year-old basketball players found significant relationships between morphological characteristics and speed-strength abilities, indicating that strength development is closely linked to athletic growth and performance potential (Djordjević et al., 2016). Therefore, resistance training programs tailored to age, training status, and playing position are recommended to support progressive strength development in basketball.

B. Speed

Speed is another essential physical attribute. Speed is an essential physical attribute in basketball, encompassing both linear sprinting ability and rapid acceleration and deceleration over short distances. Unlike continuous running sports, basketball involves frequent short bursts of high-speed movement interspersed with changes in pace and direction. Players must accelerate quickly to initiate offensive drives, sprint during fast-break transitions, and decelerate effectively to execute defensive stops or change direction to improve offensive and defensive effectiveness. For example, rapid acceleration enables players to create separation from defenders, while efficient deceleration allows them to perform sudden stop-and-go maneuvers characteristic of basketball gameplay. Straight-line sprinting is particularly important during transition phases, when players must move quickly from defense to offence or vice versa (Sheppard & Young, 2006). Empirical research on youth basketball athletes indicates that speed development progresses with age and training experience. A study of elite male players aged 12 and 14 reported significant improvements in sprint performance and agility with increasing age, highlighting the influence of neuromuscular development and structured training on speed capabilities (Jakovljevic et al., 2012). Basketball-specific speed training emphasizes explosive power production, efficient stride mechanics, and neuromuscular coordination. Training methods such as resisted sprinting, overspeed drills, and short-distance sprint intervals are commonly incorporated into conditioning programs to enhance acceleration and maximal sprint velocity. Because basketball players repeatedly perform short, high-intensity runs during games, training protocols often include repeated-sprint-ability (RSA) exercises to simulate the sport's intermittent physiological demands.

C. Agility

Agility is a complex motor ability that integrates physical movement capacity with perceptual and cognitive decision-making processes. In basketball, agility refers to the ability to rapidly change direction or body position in response to internal or external stimuli while maintaining balance and control (Young et al., 2015). This skill is essential during defensive rotations, offensive cutting, and reactive movements in response to opponents' actions. Performance involves multiple physical components, including muscular power, coordination, balance, acceleration, deceleration, and dynamic flexibility (Alvar et al., 2017). However, basketball agility is not purely mechanical; it also involves perceptual awareness and rapid decision-making. Players must constantly interpret visual and auditory cues, such as an opponent's movement, a teammate's pass, or a coach's instruction, and adjust their movements accordingly.

Research on positional differences in basketball performance shows that agility levels often vary between playing positions due to differences in physical demands and tactical roles. Guards and perimeter players typically exhibit superior agility and speed because of their responsibilities in ball handling, defensive pressure, and rapid directional changes, whereas interior players rely more on strength and power (Delextrat & Cohen, 2009; Stanković & Цанкова-калоянова, 2018).

Agility training programs frequently incorporate multidirectional movement drills, reactive stimuli exercises, and sport-specific movement patterns. Exercises such as defensive slides, close-out drills, cutting maneuvers, and reaction-based agility tasks develop both the physical and cognitive aspects of agility. Regular practice of these drills under unpredictable conditions enhances players' ability to react quickly and effectively during real-game situations (Ostojic et al., 2006).

D. Training Implications

Basketball players need to follow position-sensitive, progressive, and targeted training regimens to maximize their strength, speed, and agility. Plyometric exercises cultivate explosive power, while resistance training improves basic strength. Specialized workouts that focus on mechanics, responsiveness, and movement diversity are necessary for speed and agility.

Programming should be based on position-specific requirements; for example, guards tend to emphasize agility, quickness, and lateral movement, whilst forwards and centers may place greater emphasis on strength, vertical power, and spatial control in the post (Ostojic et al., 2006). Transfer to competitive play can also be enhanced by integrated conditioning that blends technical proficiency with physical development, for as by integrating agility exercises with ball handling. To guarantee adaptation and advancement, training should ultimately be customized, sport-specific, and routinely evaluated.

2.4.4 *Endurance and Flexibility in Basketball Player Development*

Basketball training methods emphasize strength, power, and speed since they are essential to explosive actions like sprinting, jumping, and directional shifts. For complete athletic development, endurance and flexibility are essential. These traits help maintain performance during a game, recover from high-intensity efforts, and move efficiently. Endurance and flexibility improve an athlete's resilience, movement efficiency, and injury prevention.

Basketball players perform high-intensity motions with short rests. Thus, athletes need strong physiological capacities to maintain these efforts without performance degradation. Flexibility lets athletes accomplish complex technical skills within optimal ranges of motion, reducing muscle and joint stress. Endurance and flexibility improve technical performance, competition recovery, and musculoskeletal injury risk.

A. Endurance

The ability to withstand repeated high-intensity workouts and recuperate efficiently between them is called basketball endurance. Sprinting, jumping, rebounding, and defensive slides are alternated with short rest periods in the sport. This intermittent structure strains aerobic and anaerobic energy systems. Aerobic endurance helps recover from high-intensity activities and maintain performance during extended playtime (McInnes et al., 1995). Anaerobic metabolism supports brief peak efforts.

Basketball players execute repeated sprints, accelerations, and decelerations throughout matches, requiring effective energy system interaction. A well-developed aerobic system helps athletes recover quickly between exertion, preserving speed, technical accuracy, and tactical decision-making under fatigue (Montgomery, 2010). As weariness builds, work rate, response time, and technical skill execution decrease.

Research shows that endurance boosts job capacity and game efficiency. Higher aerobic fitness allows players to undertake more high-intensity actions during games without exhaustion (Ben Abdelkrim et al., 2007). Endurance development helps athletes handle intense training and recover between sessions.

Endurance and physiological demands of basketball require basketball-specific fitness. Basketball players are advised to increase aerobic and anaerobic conditioning using HIIT, sprint training, and small-sided games (Castagna et al., 2008). These methods include tactical and technical features, making them useful for sport-specific performance enhancement. Recent basketball conditioning research emphasizes sport-specific endurance testing and training approaches. Studies show that assessment techniques must reflect the sport's intermittent and multidirectional demands (Jelicic, 2024). Team-based endurance training improves athletic performance, justifying its inclusion in long-term athlete training programs (Karjalainen, 2021).

B. Flexibility

Flexibility, governed by muscle elasticity, tendon extensibility, joint anatomy, and neuromuscular coordination, is the ability of a joint or group of joints to move freely through its whole range of motion. Basketball requires flexibility for safe and effective dynamic movements. Effective defensive stances, rapid pivots, rebounding jumps, layups, and directional adjustments demand adequate joint mobility.

Flexibility helps athletes perform technical skills with optimal biomechanics, improving efficiency and reducing muscle and joint stress. Behm & Sale (1993) found that flexibility reduces compensatory movement patterns in joints with limited range of motion. Compensations might increase the risk of overuse injuries, especially in the lower limbs and lumbar region, which are emphasized during basketball.

Flexibility improves posture, balance, and coordination, which are needed for stability during rapid, complicated movements. According to research on basketball players, flexibility positively impacts physical performance characteristics including balance and functional movement efficiency (Özer, 2019). These data suggest that basketball physical preparation programs should include flexibility.

Due to the sport's dynamic nature, basketball players have moderate to high flexibility, according to studies. Basketball players showed significant flexibility due to their movement patterns and training demands (Peltekova & Ignatov, 2018).

Basketball flexibility training is usually static and dynamic. Warm-ups usually include dynamic flexibility exercises to prepare muscles and joints for high-intensity motions during training and competition. These workouts stimulate neuromuscular function and joint mobility. Static stretching is done during cool-downs or mobility training to build flexibility and support recovery.

Structured flexibility training in basketball conditioning programs improves movement efficiency, biomechanical alignment, and injury risk. Together with strength, speed, and endurance, flexibility creates a balanced physical profile for optimal basketball performance.

2.5 Technical Skill Development in Basketball

2.5.1 Introductory preview to Basketball Technical Skills

Technical skill proficiency constitutes a fundamental aspect of basketball performance, allowing players to execute game-related actions with accuracy, efficiency, and consistency. Core basketball skills, such as dribbling, passing, shooting, rebounding, and defensive movements, form the foundation for implementing tactical strategies during gameplay (Gómez et al., 2013). Mastery of these skills enables players to maintain ball control under pressure, generate and capitalize on scoring opportunities, and respond effectively to the dynamic and unpredictable nature of competitive basketball. Therefore, the development of technical abilities is essential for both individual and team performance at all levels of play.

From a developmental perspective, technical skills are closely linked to motor learning processes and biomechanical efficiency. Skill acquisition involves repeated practice, perceptual awareness, and the gradual refinement of coordinated movement patterns. Effective execution of basketball techniques depends on the integration of physical capacities such as strength, speed, and coordination with cognitive processes that support decision-making and situational awareness (Jelicic, 2024). For instance, accurate shooting requires precise biomechanical alignment, controlled force production, and the ability to assess defensive pressure and adjust movement timing. Similarly, effective dribbling necessitates coordinated hand–eye control, spatial awareness, and rapid adaptation to defensive challenges.

Coaching literature emphasizes that technical skill development should follow a progressive and structured approach. Kathy (2007) asserts that basketball instruction must prioritize the establishment of strong fundamental skills before introducing advanced techniques and tactical applications. Foundational abilities, including ball handling, passing accuracy, and shooting mechanics, serve as the basis for more complex skills. Properly establishing these fundamental techniques equips players to perform effectively under the physical and cognitive demands of competitive environments.

Training methodologies are critical in facilitating technical development. Krause and Nelson (2019) state that effective basketball training programs should include structured drills that reinforce fundamental mechanics while gradually increasing task complexity. Repetitive practice through drills, such as ball-handling sequences, passing patterns, and shooting routines, enables players to internalize movement patterns and enhance consistency. Modern coaching approaches, however, emphasize that drills should not occur in isolation from the tactical context of the game. Instead, training should progressively incorporate elements of game realism, such as defensive pressure, decision-making requirements, and variable movement patterns. On to mechanical repetition, the teaching of technical skills should also incorporate tactical understanding and decision-making components. Hawkins et al. (2015) note that effective coaching strategies integrate both technical and tactical instruction, enabling athletes to understand not only how to perform a skill but also when and why it should be applied during competition. This integrative approach enhances the transfer of learned skills from training environments to actual gameplay, improving overall performance.

Empirical research in both recreational and competitive basketball contexts underscore the importance of technical competencies for successful gameplay. For example, Wang et al. (2010) identified fundamental skills such as dribbling control, passing accuracy, shooting consistency, and defensive positioning as essential for effective participation in adult pickup basketball games. Their findings indicate that technical proficiency is crucial for maintaining offensive flow, facilitating team coordination, and generating scoring opportunities, even in less structured environments.

The quality and structure of practice environments also influences the development of technical skills. Deliberate practice characterized by purposeful repetition, corrective feedback, and progressively challenging tasks has been widely recognized as an essential mechanism for skill development. In basketball training, contextualized drills that simulate real-game conditions help players develop adaptability and decision-making skills while reinforcing technical execution (Wang et al., 2010). For example, small-sided games, situational drills, and constraint-based training tasks can effectively replicate the perceptual and temporal demands of competitive basketball, thereby enhancing the transfer of technical skills to match situations.

As players advance through various stages of athletic development, their technical abilities should become increasingly complex and adaptable. Early developmental stages emphasize mastering basic motor skills and fundamental basketball techniques. With maturation and experience, technical execution becomes more refined and integrated with tactical understanding and game intelligence (Wang et al., 2010). This progression reflects the broader developmental pathway, wherein athletes transition from learning isolated skills to performing them automatically in complex competitive environments.

In summary, technical skill development is a central pillar of basketball performance. The acquisition and refinement of fundamental skills such as dribbling, passing, and shooting are essential for effective participation and the successful execution of tactical strategies during gameplay. These skills are influenced by motor learning processes, physical conditioning, coaching methodology, and the quality of training environments. Therefore, effective basketball development programs should emphasize structured practice, progressive skill instruction, and the integration of technical and tactical elements to support the long-term development and performance of players.

2.5.2 Fundamentals of Technical Skill Acquisition

As in many complicated sports, basketball technical skill acquisition is a steady, systematic process that develops, refines, and automates performance-related motor skills. Dribbling, passing, and shooting must be gradually learned and integrated into game circumstances where players must make quick decisions and move quickly. Motor learning theories explaining how athletes learn, refine, and stabilize movement patterns through practice and experience help this development.

Fitts and Posner's three-stage model of skill acquisition cognitive, associative, and autonomous is frequently used. Learners concentrate on skill mechanics at the cognitive stage. This stage teaches basketball fundamentals like ball handling, passing, and shooting. As athletes learn new motor patterns, performance is uneven and requires frequent feedback and intentional attention to movement execution.

Practice leads to the associative stage, where athletes polish and synchronize their motions. Players increase error correction, timing, rhythm, and movement efficiency at this stage. Associative basketball players have better ball handling, shooting mechanics, and fundamental technique fluidity. Attri (2019) states that this stage increases movement stability and reduces cognitive load, allowing athletes to focus on situational performance rather than movement mechanics.

The autonomous level is the last, when technical skills are performed automatically. Repeated repetition and motor program consolidation automate motions at this level. Basketball players can dribble while scanning the court, make rapid passes, and shoot under pressure without thinking. This automation frees up cognitive resources for tactical decision-making, anticipation, and situational awareness during play.

Practice and repetition help the nervous system create internal representations of movement patterns for these automated motor responses (Schmidt et al., 2018). As they repeat activities, athletes improve their motor programs' accuracy, coordination, and efficiency. Basketball training uses isolated and contextualized practice. Shooting mechanics and dribbling control are refined in isolated practice. Contextualized practice uses scrimmages and situational drills to test tactical awareness and decision-making (Wang et al., 2010).

Research on skill acquisition suggests that effective training environments should combine both types of practice to maximize learning. Hodges and Williams (2012) note that frequent technical drills and representative gameplay conditions assist players transfer practice skills to competition. This integration enhances adaptation and keeps technical skills effective under time and defense restrictions (Wang et al., 2010).

Feedback helps correct and improve motor performance during skill acquisition. Athletes receive intrinsic feedback from their sensory and proprioceptive systems and extrinsic feedback from coaches, video analysis, or performance tools (Magill & Anderson, 2010). Feedback helps athletes recognize movement execution faults and improve their approaches. To improve performance, film analysis and biomechanical examinations can assist players detect shooting form and body alignment inefficiencies.

Cognitive processes also shape technical skills. Basketball skills are rarely performed alone; players must evaluate visual information, predict opponents' actions, and choose proper reactions. Perceptual-cognitive talents including attention management, anticipation, and decision-making speed have been proven to boost performance even among athletes with equivalent physical traits (Vickers, 2007). These cognitive qualities help players use technical skills in high-pressure games.

Structured training for motor and cognitive development is common in skill acquisition strategies. Structured learning environments with incremental task difficulty, careful practice, and performance-enhancing instructional tools are crucial, according to Louridas (2016). Clear performance goals and remedial learning help learners progress faster through skill acquisition. Orner (2009) found that systematic training structures that integrate instruction, guided practice, and performance evaluation improve technical skill development.

Progressive learning models in basketball instruction teach players basic techniques before moving on to more advanced tactical applications. Later training includes competitive drills, small-sided games, and situational exercises that require quick perception and decision-making. Early training emphasizes basic motor coordination and skill familiarity.

This systematic strategy develops players from novices to skilled athletes who can execute technical maneuvers in competitive settings.

In summary, technical skill acquisition in basketball is a multifaceted process that involves the gradual progression from conscious skill learning to automated performance. Guided by motor learning principles, players refine their technical abilities through structured practice, repeated execution, and continuous feedback. The integration of cognitive processes, perceptual awareness, and representative training environments further enhances the transfer of learned skills to real-game situations. Consequently, well-designed training programs that combine deliberate practice, feedback mechanisms, and progressively challenging tasks are essential for the effective development of basketball technical skills and long-term athlete expertise.

2.6 Gender Differences in Basketball

Gender is a fundamental categorical factor that influences basketball performance by affecting anthropometric characteristics, physical abilities, and technical skill execution. Among both youth and elite athletes, males and females display distinct structural and functional profiles that determine role capabilities and performance outcomes on the court (Vescovi & McGuigan, 2008; Ostojic et al., 2006). These differences arise from biological maturation, hormonal influences, long-term training adaptations, and sociocultural factors that shape sports participation.

2.6.1 Anthropometric and Physical Differences in Basketball

Empirical evidence indicates that male basketball players typically exhibit greater height, body mass, skeletal muscle mass, and lower relative body fat percentages than female players of comparable age and training background (Nikolaidis et al., 2014; Vescovi & McGuigan, 2008). These structural characteristics confer mechanical advantages for actions such as rebounding, shot blocking, and explosive movement, which are especially important for interior positions such as centers and forwards. In contrast, female players generally display higher body fat percentages and lower absolute muscle mass, which may affect strength-dependent tasks but do not necessarily constrain agility or skill execution in perimeter roles when training is appropriately structured (Ostojic et al., 2006).

Physical performance metrics further underscore gender disparities. Research demonstrates that male players generally surpass female players in maximal sprint speed, lower-body power, vertical jump height, and agility assessments (Sattler et al., 2015; Vila et al., 2012). These differences are primarily attributed to greater androgen-mediated muscle development and enhanced neuromuscular efficiency in males, which provide advantages in rapid acceleration, directional changes, and forceful movements. In contrast, gender differences in endurance and technical proficiency tend to be smaller and are substantially influenced by training exposure and skill development programs (Ziv & Lidor, 2010). Implications for Technical Skill Development. Gender also modulates basketball-specific technical skills, though the patterns are more nuanced than those observed for physical or anthropometric differences. Male players often demonstrate higher absolute scores in shooting, passing, and dribbling tests, largely due to greater muscular power and speed, which facilitate forceful passes and fast breaks (Sattler et al., 2015). Nonetheless, when adjusted for relative strength or training experience, female players can achieve skill levels comparable to those of male players, particularly in precision-based or decision-making tasks (Carter et al., 2005; Nikolaidis et al., 2014). These observations indicate that while physical attributes may enhance skill execution, cognitive-motor factors such as technique, coordination, and perceptual abilities play a critical role in mitigating gender-based differences.

2.6.2 Developmental and Training Implications

Recognizing gender-based differences is crucial for youth basketball development, as it guides the creation of individualized training strategies that optimize performance and minimize injury risk. For example, male players may benefit from programs that integrate agility and skill refinement with strength and power development. Conversely, female players may require targeted neuromuscular training to improve explosive capacity and technical efficiency (Lloyd & Oliver, 2012). Addressing these distinctions aligns with long-term athlete development models, which recommend gender-sensitive approaches that account for biological maturation, anthropometric characteristics, and skill-acquisition trajectories (Vaeyens et al., 2008).

In summary, gender is a critical determinant of basketball performance, shaping both the structural and functional capacities of young athletes. Considering gender-specific differences allows coaches, trainers, and sports scientists to develop tailored programs that maximize individual potential, foster skill development, and promote equitable talent identification.

2.7 Positional Differences in Basketball

2.7.1 Role-Specific Requirements in Basketball

Positional variations are a major factor in identifying the precise technical and physical abilities that basketball players must master in order to perform at their best. The physical characteristics, skill sets, and tactical responsibilities required for the main playing positions: point guard, shooting guard, small forward, power forward, and center have an impact on a player's career path and position on the team.

Point guards are frequently referred to as the team's "floor general," and their main duties include defense, playmaking, and ball distribution. Point guards must therefore typically possess exceptional speed, agility, and ball-handling abilities. Quick passes, making snap decisions, and shooting from the outside are frequently their technical priorities (Ostojic et al., 2006). Usually renowned for their ability to score points, shooting guards also prioritize speed and agility, but they also need to pay closer attention to precision, particularly when shooting from a distance. They must create scoring opportunities, maneuver through defensive coverage, and make rapid cuts and pull-up jump shots as part of their job (Ziv & Lidor, 2009).

Due to their versatility, small forwards require a variety of talents on the court. In addition to being able to shoot from the outside, they must be agile, have the ability to handle the ball, and be able to finish at the basket. In order to contribute both offensively and defensively, this role necessitates a well-rounded technical and physical skill set (Carvalho et al., 2018). Power forwards and centers, who are usually taller and more physically strong, must be excellent at interior defense, rebounding, and post play. In order to block shots, grab rebounds, and finish in the paint, they emphasize strength and jumping ability. Their main emphasis is on physicality, posture, and controlled movements, but they also need to have rudimentary shooting skills, especially in mid-range shots (Ostojic et al., 2006).

These positional variations show how training plans should be customized to build the unique technical and physical skills required for each role.

2.7.2 Positional Profiles and Performance Demands in Youth Basketball

Basketball features guards, forwards, and centers. Each job has unique physical qualities, talents, and duties. Body type, fitness, and technical ability shape these roles and how players perform in games. Knowing these disparities helps youth basketball coaches improve training regimens, develop skill, and match players' abilities to positions.

Basketball positions vary by size and ability, according to research. Elite-level study shows that height, body mass, and physical performance meet job needs (Abdelkrim et al., 2010; Ferioli et al., 2018). These variances affect players' movements and frequently used talents. Specializing in a position requires tactical and physical ability.

On the perimeter, guards put up plays, move the ball, and create scoring chances. Their smaller size and lesser weight enable them maneuvers and change direction swiftly. These traits help them handle the ball, start fast breaks, and defend perimeter. Guards must dribble, pass accurately, and make rapid decisions under pressure. They also manage the offence and teamwork, which requires technical competence and awareness (Carvalho et al., 2018; Ziv & Lidor, 2009).

Forwards can play inside and outside. Medium-sized people must balance strength and quickness. Forwards score from mid-range, rebound, defend, and play half-court and fast-break. Forwards need many skills and physical abilities because they do so much. They train to be adaptive, gain power, improve agility, and practice shooting for their diverse roles (Carvalho et al., 2018).

Team centers are usually tallest and strongest. They play largely near the basket, where their size and muscle help. Height, long arms, and body mass enable them rebound, block shots, and score near to the rim. Strength, balance, and positioning matter more than speed or agility for centers. Muscle strengthening, basket maneuvers, and stability for severe physical play are common training goals (Ostojic et al., 2006).

Positional responsibilities have various physical and physiological demands during competition beyond structural qualities. Beyond body type, each basketball position has various physical demands throughout games, according to match-play activity patterns.

Guards perform better. When guards handle the ball and play in transition, they sprint and turn faster (Gutiérrez-Vargas et al., 2021). Forwards and centers jump, rebound, and touch more, requiring strength and power. Research demonstrates that each position has varied physical stress during sports, therefore training should match each role (Rocha et al., 2025). Positional roles affect competition mobility and skill use (Espasa-Labrador et al., 2025). Guards may cover more ground and change directions faster, while interior players may jump and fight more. Recognizing these variances lets coaches adjust training regimens to each role's physiological and technical needs.

Players improve faster with position-specific training. Guards should work on speed, agility, coordination, and ball-handling. Forwards need power, movement, and shooting practice. Centers practice strength, rebounding, and basket moves. Coaches can help players enhance their responsibilities with tailored instruction.

Positional profiling helps identify talent and plan long-term growth in addition to training. Assessing how anthropometric qualities, physical capacities, and technical skills interact within different positions helps identify talent and prepare for long-term growth. Coaches and scouts can find young players that fulfil specific roles by assessing body shape, fitness, and talents. Developers, coaches, and sports scientists may build more effective development programs that improve individual and team performance by keeping things flexible as youngsters grow and evolve. Moreover, studying positional characteristics across developmental stages helps explain how young basketball players gain the physical and technical skills needed for high-level competition.

2.8 Interplay Between Physical and Technical Skill Development in Basketball

The dynamic interaction between anthropometric characteristics and physical fitness levels, which both influence an athlete's capacity to learn and execute technical skills, must be taken into consideration in a comprehensive approach to young basketball development. Body Height, arm span, body mass, and body composition are examples of structural characteristics that offer biomechanical benefits that facilitate actions like shooting, guarding, and rebounding. Taller players with longer arms, for example, are frequently better at tasks requiring extended reach, and lower body fat increases endurance and agility (Malina et al., 2004; Ziv & Lidor, 2009).

In addition to these structural benefits, the ability to perform complicated basketball skills under game-like settings requires physical attributes such as strength, speed, agility, and explosive power.

Motor learning theory states that repeated, adaptive practice is necessary for skill acquisition (Schmidt et al., 2018). This is best achieved when an athlete's physical condition supports power, balance, and coordination. For instance, increased leg strength and explosive capability improve jumping and shooting mechanics, while increased agility improves ball-handling and defensive maneuvers (McGill et al., 2012; Sheppard & Young, 2006).

Positional demands further shape the link between technical and physical growth. While centers and forwards depend on body height and power for rebounding and post-play, guards usually need speed and coordination to dribble and shoot under pressure (Carvalho et al., 2018). Coaches can assign tasks that best suit individual talents and maximize development outcomes by matching technical training to an athlete's physical profile.

Furthermore, as neuromuscular development improves control and coordination, adolescence is a crucial time for combining technical and physical development. It is possible to guarantee that physical gains are translated into on-court performance by integrating fitness elements straight into technical drills, such as by utilizing plyometrics while shooting or agility workouts during passing.

In conclusion, it is better to see the development of technical basketball skills as a complex process that is impacted by both physical conditioning and anatomical structure.

2.9 Related Research

Basketball is a complex sport that requires a wide range of physiological, physical, and technical skills. Players' anthropometric and physical fitness profiles have a significant impact on how they develop their technical skills and allocate themselves to positions during adolescence, a time of significant growth and developmental heterogeneity. Long-term athlete development, training customization, and talent discovery are all based on the interaction of these factors.

The results of 10 pertinent research that look at the functions of anthropometric, physical, and technical factors in juvenile basketball with a focus on positional differences are integrated in the literature review that follows.

This synthesis highlights key patterns, methodological consistencies, and gaps in the current literature and situates the rationale for the present study.

2.9.1 Anthropometric and Physiological Profiling Across Playing Positions in Youth Basketball

Basketball players' anthropometric and physiological features affect their positional obligations, technical assignments, and development. Elite and youth-level studies show that physical attributes vary by status. This affects performance and customized training.

Position-specific potential is largely determined by height, wingspan, standing reach, and body mass. Cui et al. (2019) evaluated NBA combine statistics and showed that centers surpassed other positions in height (mean = 210.8 cm), arm span (mean = 223.1 cm), and reach (277.4 cm).

These structural advantages affect rebounding, shot-blocking, and post-play dominance. Adolescent centers are taller and have longer arms than guards, and Gryko et al. (2019) found that they had more biological maturity variables that contribute to early positional specialization in youth-level study.

More than stature, physiological traits distinguish positions. In terms of vertical leap ratings, forwards often have more explosive leg power than guards and centers (Cui et al., 2019). While centers excelled in strength-based exercises and vertical jumping, Mikołajec et al. (2025) found that younger athletes did better in sprint tests.

These data show that positioning needs vary by job, combining power, speed, and agility. Position-specific technical skill competency gaps are prominent. Guards are known for their ball-handling and passing accuracy, which are essential for starting plays and overcoming defensive pressure due to their lean build and quickness. Centers emphasize shot-blocking, interior scoring, and post moves, relying more on power than ability or quickness. Forwards must have a versatile skill set for interior play and perimeter shooting (Carvalho et al., 2018; Ziv & Lidor, 2009). Longitudinal and comparative research supports the physical characteristics-performance link. Hoare (2000) found that coaches' "Best" juvenile athletes, whether male and female, had better anthropometric and fitness profiles than their classmates. The same study's regression models explained over 38% of performance variance for men and 41% for women, demonstrating the importance of anthropometric profile in talent identification. Overall, basketball's positional demands necessitate a deep understanding of how physiological and anthropometric parameters affect technical requirements. Coaches should adopt position-specific training approaches that match each athlete's traits. By meeting each playing role's physical and technical needs, this strategy optimizes development and performance.

2.9.2 *Physical Fitness and Technical Skill Performance*

Basketball positions require specific physical performance characteristics. In their analysis of 60 young athletes (ages 15–18), Ili´c et al. (2022) found that while centers outperformed guards in standing vertical leap (mean = 54.8 ± 4.1 cm) and standing reach (mean = 264.3 ± 5.6 cm), guards showed superior change-of-direction speed (T-test = 9.72 ± 0.33 s). The predictive value of these metrics was confirmed when their discriminant analysis models correctly identified 88.9% of players based on physical tests.

When differentiating across competitive levels, Han et al. (2023) found moderate-to-large impact sizes for vertical leap (d = 0.49), 20m sprint (d = 0.35), and agility (d = 0.40) in their meta-analysis of nearly 3,000 youth and elite players. The VO_2 max impact size was tiny (d = 0.18), indicating that aerobic capacity had little bearing on talent differentiation.

When Stanković et al. (2022) compared players from various positions and competition levels, they discovered that while centers had higher countermovement jump heights (mean = 44.1 ± 2.9 cm), guards performed better than other positions in agility (Illinois Agility Test = 16.23 ± 0.5 s) and 10m sprint (1.73 ± 0.04 s). All factors had significant differences ($p < 0.01$) according to the ANOVA results.

2.9.3 *Anthropometry, Somatotype, and Technical Skills*

Anthropometric advantages are intimately linked to the performance of technical skills. In their 2022 study, Ivanović et al. examined 178 male players aged 12 and 14 and discovered that older players fared better in dribbling (mean = 4.98 s vs. 5.41 s; $p < 0.01$), passing (16.2

vs. 14.3 correct passes; $p < 0.05$), and defense. Height (14-year-olds = 180.4 ± 6.1 cm vs. 12-year-olds = 168.7 ± 5.3 cm) and arm span were cited as the causes of these disparities, which were strongly correlated with performance ($r > 0.45$ for the majority of skills).

Accordingly, Türkçapar (2021) discovered that mesomorphic somatotypes performed significantly better defensively (steals = 2.8 per game), rebounded (9.2 per game), and shot (76.4% accuracy) than ectomorphic players (shooting = 62.1%, rebounds = 6.1, steals = 1.3; $p < 0.05$), highlighting the practical benefit of muscular builds in the application of technical skills.

In their study of 48 young athletes, Abu Taha et al. (2023) found a strong positive relationship between reach and defensive efficacy ($r = 0.58$, $p < 0.01$), arm span and dribbling control ($r = 0.54$, $p < 0.01$), and height and shooting accuracy ($r = 0.61$, $p < 0.01$). Their regression model supported the predictive significance of somatic features by explaining 49% of the variance in combined technical skill performance.

2.9.4 Gender-based differences in basketball

Studies consistently show that gender has a strong effect on body measurements, physical abilities, and basketball skills. Female players usually have higher body fat percentages, while male players tend to be taller and have more body mass and lean muscle (Nikolaidis et al., 2014; Ostojic et al., 2006). These differences in body structure influence later performance and are seen at different levels and ages. In our study of Lebanese youth basketball players, males were taller, had more muscle, and had a higher protein-fat index than females, which aligns with earlier research.

Male athletes typically exhibit greater explosive strength, agility, and sprint speed (Ziv & Lidor, 2009; Sattler et al., 2015; Hoffman et al., 1999). Many basketball skills, such as dribbling, shooting, and defense, rely on these abilities. In our study, males performed better than females in agility, jumping, and speed, which matches global research showing that males have physical advantages for quick movements and force. However, some studies show that gender differences can vary by age and skill type. For example, Sattler et al. (2015) found that while males were better at dribbling and shooting under time pressure, passing accuracy was less influenced by gender. This suggests that skills involving perception and decision-making may depend less on physical ability.

Comparisons of technical skills show subtle trends. Ben Abdelkrim et al. (2010) found that female players did about as well as males in controlled skill tests, but males performed better in fast-break and high-intensity shooting situations. Our results support this: passing showed smaller and less consistent gender differences, especially for centers, while the biggest differences were in shooting and dribbling. This suggests that skills like passing, which rely more on technique and thinking, are less affected by gender, whereas skills that require strength and speed show larger differences. Gender differences in agility and change-of-direction speed, which may be due to differences in training exposure, developmental stage, or cultural influences. In a similar vein, Ziv and Lidor (2009) highlighted the importance of practice and experience in the acquisition of technical skills, implying that observed variations in structured training and participation opportunities can partially explain gender disparities.

Overall, these studies agree that gender strongly affects basketball performance, mainly because of differences in body structure and physical ability, which influence how skills are performed. Our study of young Lebanese players supports this, showing that some technical skills, especially those needing coordination and decision-making, are less influenced by gender. This shows why training programs should be tailored to each gender’s strengths and needs to help all athletes develop fairly and succeed in the long term (Ostojic et al., 2006; Sattler et al., 2015; Nikolaidis et al., 2014; Ziv & Lidor, 2009).

2.10 Concluding Synthesis of the Literature Review

Existing literature highlights the significant influence of anthropometric and physical characteristics on basketball performance, with particular emphasis on technical skill development and positional specialization. Height, wingspan, and standing reach are identified as primary structural determinants for interior players, such as forwards and centers, who gain mechanical advantages in rebounding, shot-blocking, and scoring near the basket (Cui et al., 2019; Gryko et al., 2019). In contrast, guards and perimeter-oriented forwards are more closely associated with speed, agility, and explosive power, which correspond to their responsibilities in fast-paced transitions, defensive coverage, and open-court play (Ivanović et al., 2022; Stanković et al., 2022). Furthermore, body composition, particularly a mesomorphic profile along with age and biological maturation, facilitates coordinated movement, motor control, and the execution of technical skills such as dribbling, passing, and shooting (Türkçapar, 2021).

Multivariate approaches, such as discriminant and regression analyses, have shown that combinations of anthropometric and physical variables account for a substantial proportion of variance in technical skill performance, sometimes ranging from 49% to 89%. This underscores their predictive value in player development (Garcia-Gil et al., 2018). These findings emphasize the necessity of comprehensive profiling in youth basketball, integrating morphological and functional characteristics to inform position-specific training and talent identification program. Despite these advances, significant gaps persist in the literature. Most existing research has focused on Western or elite populations, limiting the generalizability of findings to other cultural and developmental contexts. Few studies have systematically compared anthropometric, physical, and technical factors across multiple playing positions in youth populations outside North America and Europe. Additionally, the combined effects of body composition, physical fitness, and skill performance remain insufficiently explored, particularly in region-specific contexts such as the Middle East.

Recent evidence highlights the impact of gender on basketball performance, demonstrating consistent differences in anthropometric, physical, and technical profiles. Male players typically exhibit greater stature, body mass, skeletal muscle mass, and lower body fat, as well as superior physical abilities such as speed, agility, and explosive power (Nikolaidis et al., 2014; Ostojic et al., 2006; Ziv & Lidor, 2009). Technical skills like dribbling and shooting often favor male players, especially in high-intensity, strength-dependent situations, whereas passing performance appears less influenced by gender, suggesting a more substantial role for perceptual-cognitive factors (Sattler et al., 2015; Ben Abdelkrim et al., 2010). These findings suggest that gender should be considered alongside position and training history in the design of individualized development programs and performance assessments.

By incorporating both positional and gender perspectives, the present study addresses these gaps and provides a comprehensive evaluation of Lebanese youth basketball players across all primary positions. The research investigates the combined effects of anthropometry, physical fitness, and technical skills, offering culturally specific insights that enhance ecological validity. The anticipated findings aim to inform evidence-based talent identification, guide position- and gender-specific training interventions, and support long-term athlete development frameworks within Lebanon and similar regional contexts.

This study advances the existing literature in several key ways. First, whereas previous research has typically examined anthropometric, physical, or technical variables in isolation, the present study employs an integrated analytical approach by simultaneously evaluating anthropometric characteristics, physical fitness attributes, and basketball-specific technical skills within a single population. This comprehensive framework enables a more nuanced understanding of the interactions among these factors in shaping youth basketball performance.

Second, the study offers region-specific empirical data on Lebanese youth basketball players, a group that is largely underrepresented in international sport science research. Most prior studies have focused on European, North American, or elite professional cohorts, limiting the applicability of their findings to developing basketball systems elsewhere. By focusing on athletes in the Lebanese context, this research broadens the geographical and cultural scope of basketball performance studies and enhances ecological validity.

Third, the study compares players across all major playing positions and accounts for gender differences, providing a multidimensional perspective on performance determinants. This dual focus facilitates a more detailed understanding of how positional roles and biological differences shape anthropometric profiles, physical capacities, and the execution of technical skills during youth development. But practical implications for talent identification, player development, and training design. By identifying key physical and technical characteristics associated with specific playing positions and gender categories, the study provides coaches and sport practitioners with evidence-based criteria for athlete selection and position-specific training programs, supporting the long-term development of basketball players in Lebanon and similar emerging basketball environments.

3 CHAPTER THREE: PROBLEM, PURPOSE, OBJECTIVES, HYPOTHESES, AND SIGNIFICANCE OF THE STUDY

3.1 Defining the Problem

Technical skills, physical abilities, and anthropometric characteristics all play a significant role in the development of young basketball players (16-18 years). Anthropometric measurements were very important for skills and body tests. These characteristics were found to significantly contribute to the skills and performance of pre-adolescent players (Abu Taha et al., 2023; Ivanović et al., 2022; Jakovljevic et al., 2011; Karalejic et al., 2011). However, it is not well known enough how these elements interact and differ at other positions (e.g., guards, forwards, and centers). Although performance depends on the development of technical skills, it is not clear enough how physical characteristics (such as height and body composition) and physical aptitudes (such as strength, speed, and agility) affect these skills, especially in young athletes going through growth and skill acquisition. The capacity to design specialized training programs that meet the requirements of particular roles and developmental phases is hampered by this information gap. To maximize youth basketball training and ensure players are adequately equipped to meet the technical and physical demands of their positions, this issue must be resolved.

This research problem statement is not limited to Lebanese youth basketball. After reviewing the literature in this field of science (especially the studies below), we could say that future research should explore the long-term effects of growth, anthropometric traits, and physical abilities across age groups and playing positions. Further studies should evaluate training modalities, nutrition, and socioeconomic influences, use advanced measurement technologies, include gender comparisons, and involve larger, diverse samples to develop holistic, evidence-based approaches to youth basketball development.

3.2 Purpose of the Study

Given the gaps in the literature, the purpose of this dissertation is to investigate the relationships among certain anthropometric characteristics and physical abilities, and to determine their impact on basketball-specific skills among young Lebanese basketball players, by gender and playing position. Specifically, the study aims to analyze how body composition impacts key technical skills such as shooting, dribbling, and passing, while also examining the contributions of agility, power, and speed to the development and execution of these skills. Furthermore, the research seeks to assess the proficiency of these skills in relation to both anthropometric and fitness factors and explore the relationships through statistical and multivariate analyses. The study will also investigate how these relationships vary by gender and playing position, providing practical insights for coaches to design individualized training programs that optimize both physical attributes and skill development to improve game performance.

3.3 Objectives of the Study

1. Determining the body composition parameters in Lebanese young basketball players and analyzing how these parameters influence performance in: shooting, dribbling, and passing.

2. Determining the physical abilities: agility, power, and speed in Lebanese young basketball players and examining the contribution of these abilities to the development and execution of the aforementioned technical basketball skills

3. Assessing the quality of basketball skills of young Lebanese basketball players including shooting accuracy, passing effectiveness, dribbling control, and how these are influenced by both morphology and fitness.

4. Investigate the relationships between anthropometric characteristics, physical fitness levels, and technical skill performance by conducting statistical and multivariate analyses to explore how these elements interact to influence overall performance.

5. Investigate how these relationships differ across various categorical variables like gender and playing position, focusing on how these variables impact the balance between physical attributes and skill acquisition.

6. Offer practical insights into how coaches can design tailored training programs that account for the individual anthropometric and fitness profiles of players, aiming to enhance technical skills and overall game performance in youth basketball.

3.4 Hypotheses of the Study

The defined general hypothesis is:

- GH: Anthropometric characteristics and physical abilities are independent factors that statistically significantly affect the key basketball-specific skills: shooting, dribbling, and passing in Lebanese young basketball players according to gender and playing position.

The supporting hypotheses are:

- H1: Anthropometric Characteristics (BH, BW, BMI, PBFM, PSMM, and PFI) significantly affect shooting performance in Lebanese young basketball players.

- H2: Anthropometric Characteristics (BH, BW, BMI, PBFM, PSMM, and PFI) significantly affect dribbling performance in Lebanese young basketball players.

- H3: Anthropometric Characteristics (BH, BW, BMI, PBFM, PSMM, and PFI) significantly affect passing performance in Lebanese young basketball players.

- H4: Physical abilities (agility, power, and speed) significantly affect shooting performance in Lebanese young basketball players.

- H5: Physical abilities (agility, power, and speed) significantly affect dribbling performance in Lebanese young basketball players.

- H6: Physical abilities (agility, power, and speed) significantly affect passing performance in Lebanese young basketball players.

- H7: Gender is a categorical variable that significantly impacts the relationship between Physical abilities, Anthropometric Characteristics, and key basketball-specific skills in Lebanese young basketball players.

- H8: Playing Position is a categorical variable that significantly impacts the relationship between Physical abilities, Anthropometric Characteristics, and key basketball-specific skills in Lebanese young basketball players

4 CHAPTER FOUR: METHODS

4.1 Design and Approach of the Study

Using a deductive quantitative approach and an applied non-experimental cross-sectional research design, this study uses numerical data to analyses particular real-world scenarios by applying established theories. Creswell (2014) states that when researchers want to characterize characteristics, trends, or relationships between variables without changing them, they frequently employ an applied deductive quantitative research design, especially a cross-sectional descriptive study.

4.2 Sample Characteristics

Based on the Lebanese basketball teams' national league lists addressed by the Lebanese Basketball Federation in 2024, it was determined that 1275 Lebanese professional young players are presenting the 16-18 years varsity population. These players are distributed among 66 male basketball clubs, and 18 female basketball clubs (Appendix 1). To obtain the appropriate number of respondents, a statistical calculator based on the reference sample size technique was used and a sample of 260 participants was determined, which is considered representative at a confidence level of 95%, with a standard error of 5%. The respondents were divided by gender: one hundred and sixty male players (n=160) and one hundred female players (n=100) recruited from all youth basketball clubs.

In the sample of male players, the 160 players were distributed as follows: 36 guards, 79 forwards and 45 centers, while the female players were distributed as: 26 guards, 46 forwards and 28 centers.

The respondents were regularly registered players who have been training regularly for at least three years and are currently injury-free.

4.3 Data Collection and Testing Procedures

4.3.1 Data Collection Procedures

The data were gathered in April 2025. The purpose of the data collection was explained to the participants, and their information wouldn't only be analyzed if they consented to participate in the study. The study was conducted in compliance with the Declaration of Helsinki's conditions, guidelines for doctors conducting biomedical research on human subjects (World Medical Association, 2013), and ethical approval number 835-2 of the University of Belgrade's Faculty of Sport and Physical Education's Ethical board. The study's ethical approval was included in Appendix 2.

4.3.2 *Testing Procedures (Variables)*

4.3.2.1 Anthropometric Measurements: Body Composition

Body composition parameters include 6 variables where 2 are basic: (1) Body height (BH) presented in cm; and 2) Body weight (BW) presented in kg, and 4 are calculated as index values as follows:

- Body mass index (BMI), presented in kg/m^2;

- Percentage of body fat (PBFM) presented as body fat Mass (BFM) relative to BW, calculated as: (BF/BW) * 100 = PBF (%)

- Percentage of skeletal muscle mass (PSMM) presented as skeletal muscle mass (SMM) relative to BW, calculated as: (SMM/BW) * 100 = PSMM (%)

- Protein Fat Index (PFI) presented as PM relative to BFM, calculated as: PFM/BFM = PFI (kg)

In order to explain the body structure at the tissue level, regardless of body height and weight, the index-values approach was used. The InBody 270 (Biospace Co. Ltd., Seoul, Korea) and the Bioelectrical Impedance Analysis method was used to determine basic and derived body composition variables (Hu, 2008). This instrument is highly precise and has been utilized in numerous related studies, including those conducted by Kim et al. (2021).

After that, the respondents did the previously mentioned body composition measures while standing on the scale with their hands on the designated locations and their bare feet. The pupils were told not to eat or drink anything for at least three hours before the measurement in order to ensure maximum accuracy. Following the normal procedure, a fixed stadiometer was used to measure the body height. The subjects were clad in light clothing, and their body mass was measured to the closest 0.1 kg. As stated, and covered in the pertinent procedure, barefoot, standing height was measured using a wall-mounted stadiometer to the closest 0.5 cm (Kukić & Dopsaj, 2017).

4.3.2.2 Physical Abilities:

Anaerobic Power: Vertical Jump Height Test Instrument

Using an adjustable measuring device and the jump-and-reach method (Vertec, Inc., Falls Church, VA), Figure 1 shows the vertical jump height. In order to show real progress over the course of the training cycle, the Vertec vertical jump tester is a flexible and precise device that measures vertical jumps within 12 inches. It is a portable, low-cost, and straightforward tool for figuring out an athlete's vertical leap height.

Peak power Tests Vertical jump peak power (Harman et al., 1991) using Vertec Jump Measuring Device

Every participant underwent a controlled warm-up consisting of three practice leaps at maximal effort, stretching, and jogging. Three test leaps were performed on each individual, separated by a two-minute rest period. For every jump, subjects were permitted to countermove with their arms and legs. For vertical jump height, the test-retest intraclass correlation coefficient was 0.9608 (ἀ = 0.9800). The Harman et al. (1991) formula, which computed peak power through multiple regression processes as (61.9 x jump height cm) + (36 x body mass kg) + 1822, was used to determine vertical jump peak power. The vertical jump power tests had an intraclass correlation value of 0.9754 (ἀ = 0.9875). The jumps of the subject were captured on video.

Figure 1. Vertec Jump Measuring Device

4.3.2.3 Agility

Measurement of Agility (T-Drill Test)

The subjects tried the test at low speed after 5–6 minutes of free warming, and then they joined the test at random. The T-drill test track measured 9.14 meters (10 yards) in length and breadth. The third and fourth cones were positioned on the right and left sides of a cone that was pushed forward 9.14 meters vertically from the starting point to create the course. The athletes begin the test by running straight from the starting cone to the second cone, which is 9.14 meters distant.

The player next makes side runs to the left-side cone, which is 4.57 meters away, and touches it with the left hand. Next, the player makes side runs to the right-side cone, which is 4.57 meters away from the middle cone, and touches it with the right hand. The test concludes when the side run reaches the middle cone and touches it with the left hand before running back to the starting cone. (Pauole et al., 2000). Figure 2 displayed the T-Drill Agility test configuration.

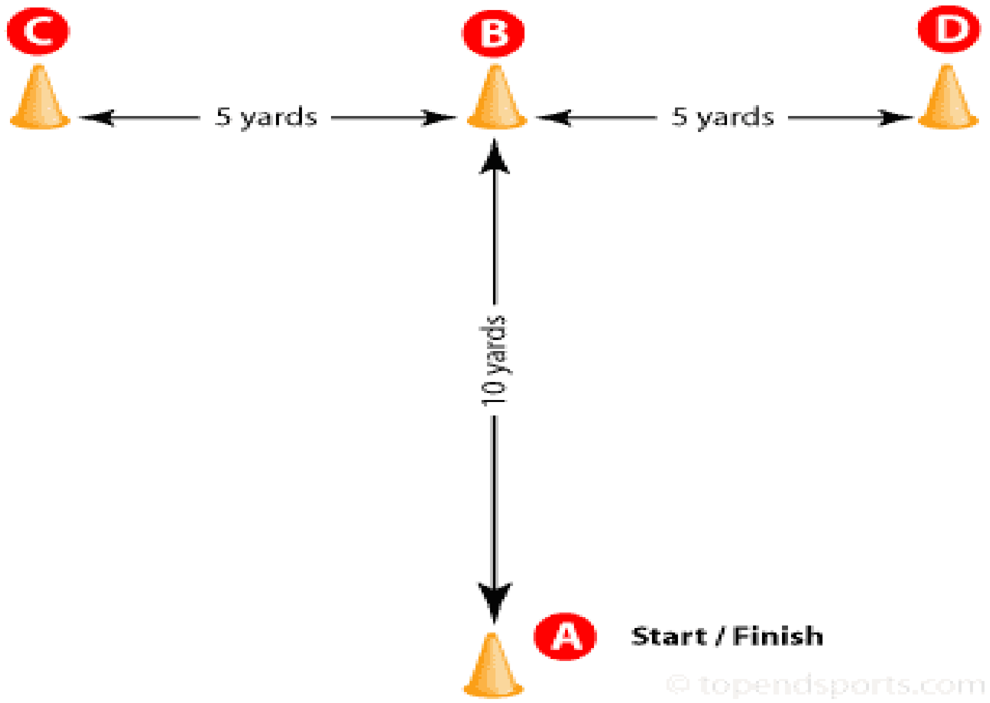

Figure 2. T-Drill Agility Test Settings

20m Sprint Test:

A 20-meter straight-line sprint from a three-point, crouching stationary start was used to measure sprint time, and a split time was taken at 10 meters (Moir and Glaister, 2004). Telemetric photocells (Sprint Timer Telemetry, Cranlea & Co., UK) were positioned at the 0-, 10-, and 20-meter markers of an indoor running track in order to measure sprint times. Each participant completed three maximal sprints; the analysis that followed used the mean timings for the first 10 m, second 10 m, and total 20 m. The participants started each sprint on their own initiative, and there was a three-minute recuperation period in between.

Under the supervision of an instructor, participants completed a standardized warm-up that included running, followed by particular static exercises, dynamic exercises, and sprint drills, prior to the sprints. It has been demonstrated that 10- and 20-meter sprint time measures exhibit low within-participant variation and good test-retest reliability without requiring familiarization with this methodology (Moir and Glaister, 2004).

4.3.3 Basic Basketball Skills:

The Association for Research, Professional Councils, American Alliance for Health, & Dance (1984), Technical manual, health related physical fitness. American Alliance for Health, Physical Education, Recreation & Dance has developed a battery of tests that will be used to examine the four basketball-specific skills of shooting, passing, and dribbling. These tests were utilized in numerous research papers, particularly by Karalejic et al. (2011) and Erčulj et al. (2024), and demonstrated great validity and reliability.

A. Shooting:

The individual begins the 60-second speed spot shooting test (Figure 3) from one of the specified sites at a distance of 3.65 meters. The subject shoots at the signal, then dribbles to another position and shoots again after going to get the ball. The player makes four lay-ups and a jump shot, but not two consecutive ones. A hit from the first shot is worth two points, whereas a missed first shot is worth one point. The test taker must first make at least one shot from each point. The final result is the sum of the points from the two tries. The work is completed three times, with the first two being trials and the second two being scored.

B. Dribbling:

In the control dribble test, participants are given the challenge of dribbling through the polygon in Figure 4 as quickly as they can. Starting from cone A, the participant's "weaker hand" side, they dribble along the path depicted in Figure 2 at the timekeeper's signal, always using the hand that is furthest from the cone. Following one trial effort, the participant completes the task twice again, and the total time (in seconds) is the sum of the timings attained during these two attempts.

C. Passing:

Figure 5 displays the 30-second passing test; the distances in the picture are measured in centimeters. The ball-carrying subject stands behind the queue in front of target A, passes from the chest to target A, catches the ball that bounces off the wall, moves laterally to target B, passes it, and repeats the process to target F, where he makes two passes, then returns to target A, where he makes two passes, and so on. A hit on the target or within the target's frame earns two points, whereas a hit outside the target earns one point. The total of the points from the final two attempts is the outcome; the first try is a trail, and the subsequent two are scored.

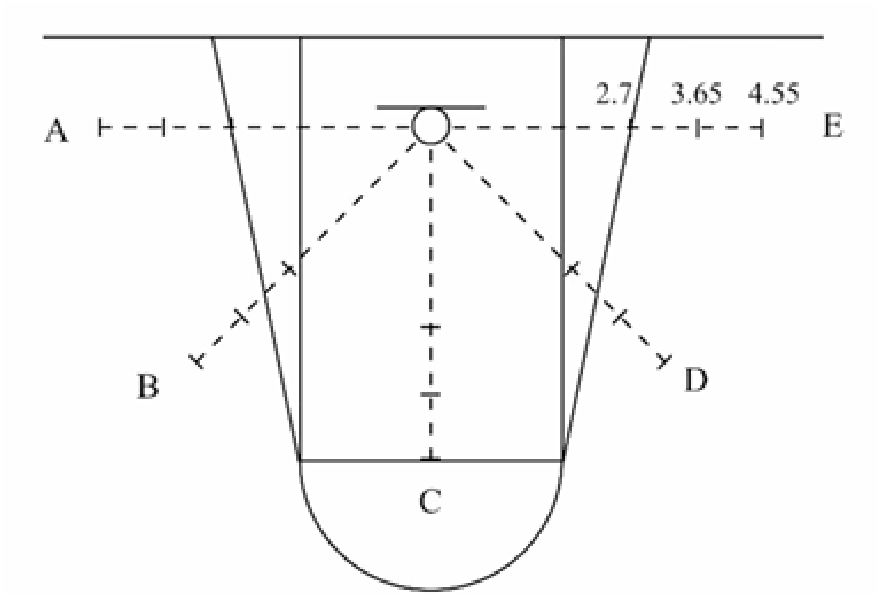

Figure 3. The speed spot shooting test

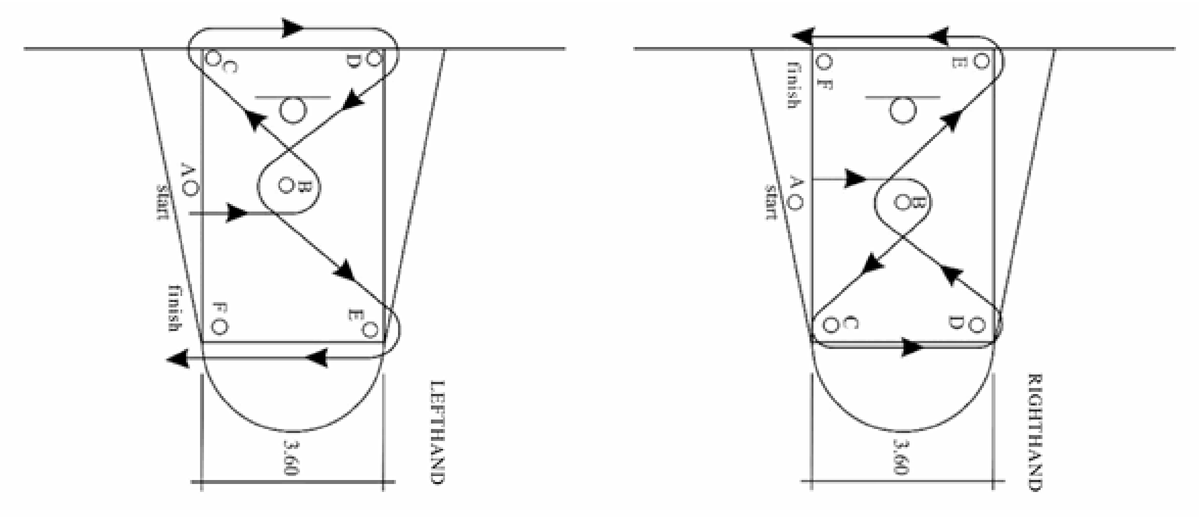

Figure 4. The control dribble test

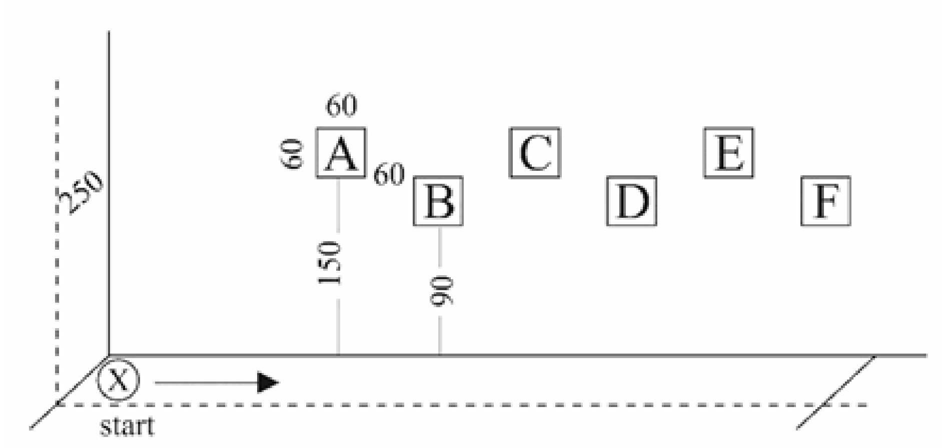

Figure 5. The Passing Test

4.4 Statistical Procedures

All statistical analyses were performed using IBM's Statistical Package for the Social Sciences (SPSS, version 26). A significance level of $p < 0.05$ has been established. Descriptive statistics: the mean, standard deviation (SD), minimum (min), maximum (max), coefficient of variation (cV%), and Kolmogorov-Smirnov test for distribution homogeneity (KST) were used to provide the measures of central tendency and variability. However, the following statistical methods were used to determine the inferential statistics that cover the relationships, significant differences, and predictions among the variables: independent samples t-test, Analysis of Variance (ANOVA), Multivariate Analysis of Variance (MANOVA), Pearson and Spearman correlation, and, lastly, Multiple Regression Analysis (MRA).

5 CHAPTER FIVE: RESULTS

5.1 Descriptive Statistics

5.1.1 Socio-demographic Results

The socio-demographic characteristics of the total sample were presented in Table 1. The sample consisted of 235 Lebanese youth basketball players, including 142 males (60.4%) and 93 females (39.6%). The comparison between male and female participants revealed no statistically significant differences across any of the examined socio-demographic variables ($p > .05$), indicating that the two groups were demographically comparable.

The mean age was nearly identical between males (17.1 ± 0.8 years) and females (17.0 ± 0.8 years) ($p = .675$), confirming that both groups were at a similar developmental stage. Regarding place of residence, the majority of participants in both groups lived in urban areas (males: 79.6%; females: 80.6%), with no significant sex-based differences ($p = .842$). This suggests a predominantly urban context for basketball participation within the sampled population.

In terms of school class distribution, players were relatively evenly spread across 1st, 2nd, and 3rd secondary levels, with comparable proportions between males and females ($p = .722$). Similarly, most participants attended private schools (males: 88.0%; females: 89.2%), while a smaller percentage were enrolled in public schools, with no significant group differences ($p = .776$). This reflects the strong representation of private educational institutions within the sample.

Parental education levels were also similar across sexes ($p = .821$). Approximately one quarter of parents had an education below high school, around 40% had completed high school, and roughly one third held university degrees. This distribution suggests a moderate-to-high level of education among the families of participating athletes.

Finally, parental basketball background did not significantly differ between male and female players ($p = .686$). The majority reported that neither parent had played basketball (males: 58.5%; females: 63.4%), while approximately 29% indicated that one parent had played basketball, and a smaller proportion reported that both parents had played.

Overall, the absence of significant sex differences across socio-demographic variables indicates that the male and female subsamples were well-matched. This comparability strengthens the validity of subsequent analyses examining anthropometric, physical, and technical performance differences, as potential confounding effects of socio-demographic disparities are minimized

Table 1. *Demographics: Sample characteristics*

Variable	Sample Mean±SD Males	 Mean±SD Females	p value
Gender #			
Males	142		
Females		93	
Age (Years)			
	17.1±0.8	17.0±0.8	0.675
Place of Living (%)			
City	79.6	80.6	0.842
Village	20.4	19.4	0.842
School Class (%)			
1st Secondary	31.7	30.1	0.722
2nd Secondary	31.7	38.7	0.722
3rd Secondary	36.6	31.2	0.722
School Educational Sector (%)			
Public	12.0	10.8	0.776
Private	88.0	89.2	0.776
Parents Education Level (%)			
Below High School	24.6	24.7	0.821
High School Level	40.1	37.6	0.821
University Level	35.2	37.6	0.821
Parents Basketball Background (%)			
None Played Basketball	58.5	63.4	0.686
1 parent was a Basketball Player	28.9	29.0	0.686
2 parents were Basketball Players	12.7	7.5	0.686

Table processed by the Author

5.1.2 Anthropometric, Physical, and technical skills profiles of the Lebanese Basketball Players according to gender and playing position.

Table 2 presents the descriptive statistics for female Lebanese youth basketball players (n = 142) across three playing positions: guards, forwards, and centers. The mean age of the sample was relatively homogeneous across positions, ranging from 16.9 ± 0.8 years for centers to 17.1 ± 0.8 years for guards. Anthropometric measures showed clear positional trends: centers were the tallest (177.7 ± 5.5 cm), followed by forwards (171.5 ± 4.7 cm) and guards (164.3 ± 4.1 cm). Body mass was fairly similar across positions, with guards and forwards both averaging 65.4 ± 6.8–7.2 kg, while centers were slightly lighter at 63.4 ± 6.1 kg.

Percentage of body fat mass (PBFM) and skeletal muscle mass (PSMM) showed minor variation between positions: centers had slightly higher PBFM (21.4 ± 3.3%) and lower PSMM (36.8 ± 3.5%) compared to guards (PBFM: 20.7 ± 3.7%; PSMM: 38.8 ± 3.8%) and forwards (PBFM: 20.4 ± 4.3%; PSMM: 37.5 ± 4.1%). BMI values reflected these differences, with guards showing the highest BMI (23.4 ± 2.8), forwards intermediate (22.3 ± 2.5), and centers the lowest (20.0 ± 2.3).

Physical performance and technical skills were relatively consistent across positions. Agility and vertical jump power were comparable (Agility: 12.2 ± 0.5–0.6 s; Vertical Jump Power: 6173–6352 W). Speed, speed spot shooting (SS), control dribble (CD), and passing score (PS) showed minimal variation, suggesting a homogeneous skill level across positions in this female sample. Overall, while anthropometric measures, particularly height and BMI, varied by position, physical abilities and technical skills remained consistent.

Table 2. *Arithmetic means, standard deviations of age, anthropometric measurements, physical abilities, and Technical Skills of Female Basketball Players (n=93)*

Variable	**Mean + SD**			**Total**	**KST**
	Guards	**Forwards**	**Centers**		
Age	17.1±0.8	17.0±0.8	16.9±0.8	17.0±0.8	0.000
BH (cm)	164.3±4.1	171.5±4.7	177.7±5.5	172.2±6.1	0.200
BM (kg)	65.4 ± 6.8	65.4 ± 7.2	63.4 ±6.1	64.9±6.9	0.200
PBFM (%)	20.7 ± 3.7	20.4 ±4.3	21.4±3.3	20.8 ± 3.9	0.200
PSMM (%)	38.8 ± 3.8	37.5 ± 4.1	36.8 ± 3.5	37.6 ± 3.9	0.200
BMI	23.4± 2.8	22.3± 2.5	20.0± 2.3	22.0± 2.8	0.200
PFI	1.9± 0.5	1.9± 0.5	1.8± 0.3	1.9± 0.4	0.004
Agility	12.2± 0.5	12.2± 0.6	12.2± 0.5	12.2± 0.6	0.200
Vertical Jump Power (Watts)	6352±315	6311±332	6173±371	6279±339	0.200
Speed	3.4± 0.2	3.5±0.2	3.5±0.2	3.5±0.2	0.200
Speed Spot Shooting (SS)	14.7 ± 3.4	15.1 ± 4.1	16.1 ± 4.1	15.3 ± 4.0	0.175
Control Dribble/s (CD)	12.4 ± 0.9	12.7 ± 1.0	12.5 ± 1.0	12.6 ± 1.0	0.200
Passing Score (PS)	20.7 ± 3.7	20.3 ± 2.9	21.2 ± 2.0	20.6 ± 2.9	0.000

BH: Body Height, BM: Body Mass, BMI: Body Mass Index, PBFM: Percentage of Body Fat, PSMM: Percentage of Skeletal Muscle Mass, KST: Kolmogorov Smirnov test for distribution homogeneity

Table 3 summarizes descriptive statistics for male Lebanese youth basketball players (n = 93). Similar to females, the mean age was consistent across positions (17.0–17.1 ± 0.8 years). Clear positional trends were observed in body height, with centers being the tallest (191.8 ± 4.2 cm), followed by forwards (183.7 ± 3.3 cm) and guards (176.8 ± 4.8 cm). Body mass showed minor differences (77.6–79.2 kg), while BMI reflected positional trends in height and mass, with guards showing the highest BMI (24.9 ± 2.5), forwards intermediate (23.5 ± 2.6), and centers the lowest (21.2 ± 2.7).

Body composition variables such as PBFM (12.3–12.8%) and PSMM (44.1–44.8%) were fairly stable across positions. Physical performance measures, including agility (11.5–11.6 s), vertical jump power (7685–7775 W), and speed (3.1–3.2 s), exhibited minimal variation.

Similarly, basketball-specific technical skills (SS, CD, PS) were comparable across guards, forwards, and centers.

Overall, both male and female samples displayed positional differences primarily in anthropometric measures, particularly body height and BMI, whereas physical performance and basketball-specific technical skills were largely uniform across playing positions. These descriptive statistics provide context for the subsequent inferential analyses examining the effects of position on physical, anthropometric, and skill variables.

Table 3. *Arithmetic means, standard deviations of age, anthropometric measurements, physical abilities, and Technical Skills of Male Basketball Players (n=142)*

Variable	Mean + SD			Total	KST
	Guards	Forwards	Centers		
Age	17.1±0.8	17.0±0.8	17.1±0.8	17.1±0.8	0.000
BH (cm)	176.8±4.8	183.7±3.3	191.8±4.2	184.5±6.6	0.200
BM (kg)	77.6 ± 7.2	79.2 ± 8.2	77.8 ±9.2	78.5±8.3	0.200
PBFM (%)	12.3 ± 2.9	12.5 ±2.7	12.4±2.8	12.8 ± 2.8	0.200
PSMM (%)	44.2 ± 4.5	44.8 ± 5	44.1 ± 4.4	44.5 ± 4.7	0.200
BMI	24.9± 2.5	23.5± 2.6	21.2± 2.7	23.1± 2.9	0.200
PFI	3.7± 0.93	3.8± 1.1	3.9± 1.2	3.8± 1.1	0.000
Agility	11.6± 0.5	11.5± 0.5	11.6± 0.5	11.6± 0.5	0.200
Vertical Jump Power (Watts)	7775±455.5	7703±470.5	7685.5±376	7684±443	0.025
Speed	3.1± 0.2	3.2±0.2	3.2±0.2	3.2±0.2	0.200
Speed Spot Shooting (SS)	17.8 ± 3.6	17.6 ± 3.9	17.8 ± 3.7	17.7 ± 3.8	0.097
Control Dribble/s (CD)	11.5 ± 0.79	11.6 ± 1.0	11.3 ± 1.0	11.5 ± 1.0	0.200
Passing Score (PS)	22.2 ± 2.5	22.8 ± 3.0	22.5 ± 2.6	22.2 ± 2.8	0.002

BH: Body Height, BM: Body Mass, BMI: Body Mass Index, PBFM: Percentage of Body Fat, PSMM: Percentage of Skeletal Muscle Mass, KST: Kolmogorov Smirnov test for distribution homogeneity

5.2 Anthropometric and physical parameters according to gender and playing position

5.2.1 Gender-based differences

To check the 7th Hypothesis: H7: Gender is a categorical variable that significantly impacts the relationship between Physical abilities, Anthropometric Characteristics, and key basketball-specific in Lebanese young basketball players", the Independent T-Test Technique has been used.

A1. Gender-Based Differences in Guards (Table 4)

Table 4 presents the independent t-test comparisons between male and female basketball players competing in the guard position. Significant gender-based differences were found across nearly all anthropometric, physical, and technical variables ($p < .05$).

From an anthropometric perspective, male guards were significantly taller (176.8 ± 4.8 cm vs 164.3 ± 4.1 cm, p = .000), heavier (77.6 ± 7.2 kg vs 65.4 ± 6.8 kg, p = .000), and demonstrated lower body fat percentage (12.3 ± 2.9% vs. 20.7 ± 3.7%, p = .000) compared to females. Additionally, males showed higher skeletal muscle mass percentage (44.2 ± 4.5 vs 38.8 ± 3.8, p = .000), higher BMI (24.9 ± 2.5 vs 23.4 ± 2.8, p = .000), and greater protein-fat index (3.7 ± 0.93 vs 1.9 ± 0.5, p = .000), signifying a more muscular body composition profile.

Regarding physical abilities, male guards outperformed females in agility (11.6 ± 0.5 s vs 12.2 ± 0.5 s, p = .003), explosive power (7775 ± 455.5 vs 6352 ± 315, p = .000), and sprint speed (3.1 ± 0.2 s vs 3.4 ± 0.2 s, p = .000), reflecting superior neuromuscular performance.

In terms of basketball-specific skills, male guards demonstrated significantly higher shooting (17.8 ± 3.6 vs 14.7 ± 3.4, p = .043) and passing (22.2 ± 2.5 vs 20.7 ± 3.7, p = .009) scores. Conversely, female guards recorded significantly slower control dribble times (12.4 ± 0.9 s vs 11.5 ± 0.79 s, p = .011), indicating lower dribbling efficiency. Overall, gender differences among guards were consistent, favoring males across structural, functional, and performance domains.

Table 4. *Gender – based Significant differences of All Variables for (Guard) Basketball Players*

Total Sample Characteristics		**All Sample (235)**				**p value**
		Males		**Females**		
		Mean	**SD**	**Mean**	**SD**	
Anthropometric Measurements	BH	176.8	4.8	164.3	4.1	**0.000**
	BM	77.6	7.2	65.4	6.8	**0.000**
	PBFM	12.3	2.9	20.7	3.7	**0.000**
	PSMM	44.2	4.5	38.8	3.8	**0.000**
	BMI	24.9	2.5	23.4	2.8	**0.000**
	PFI	3.7	0.93	1.9	0.5	**0.000**
Physical Abilities	Agility	11.6	0.5	12.2	0.5	**0.003**
	Power	7775	455.5	6352	315	**0.000**
	Speed	3.1	0.2	3.4	0.2	**0.000**
Basketball-specific technical skills	Speed Spot Shooting (SS)	17.8	3.6	14.7	3.4	**0.043**
	Control Dribble/s (CD)	11.5	0.79	12.4	0.9	**0.011**
	Passing Score (PS)	22.2	2.5	20.7	3.7	**0.009**

A2. Gender-Based Differences in Forwards (Table 5)

Table 5 presents gender-based comparisons for players in the forward position. Similar to guards, statistically significant differences were observed across all anthropometric and physical variables and most technical skills ($p < .05$).

Male forwards were significantly taller (183.7 ± 3.3 cm vs 171.5 ± 4.7 cm, p = .000) and heavier (79.2 ± 8.2 kg vs 65.4 ± 7.2 kg, p = .000) than female forwards. They also exhibited lower body fat (12.5 ± 2.7% vs. 20.4 ± 4.3%, p = .000), higher skeletal muscle mass (44.8 ± 5.0 vs 37.5 ± 4.1, p = .000), higher BMI (23.5 ± 2.6 vs. 22.3 ± 2.5, p = .000), and higher protein-fat index (3.8 ± 1.1 vs. 1.9 ± 0.5, p = .000). These findings reflect clear gender-based structural differences within this position.

In physical performance, males demonstrated superior agility (11.5 ± 0.5 s vs 12.2 ± 0.6 s, p = .003), greater explosive power (7703 ± 470.5 vs 6311 ± 332, p = .000), and faster sprint speed (3.2 ± 0.2 s vs. 3.5 ± 0.2 s, p = .000).

Technically, male forwards achieved significantly higher shooting scores (17.6 ± 3.9 vs 15.1 ± 4.1, p = .000) and passing scores (22.8 ± 3.0 vs 20.3 ± 2.9, p = .007). At the same time, females recorded slower control dribble times (12.7 ± 1.0 s vs 11.6 ± 1.0 s, p = .000). The magnitude and consistency of these differences further confirm that gender significantly influences anthropometric characteristics, physical abilities, and most technical performance indicators within the forward position.

Table 5. *Gender – based Significant differences of All Variables for (Forward) Basketball Players*

Total Sample Characteristics		**All Sample (235)**				**p value**
		Males		**Females**		
		Mean	**SD**	**Mean**	**SD**	
Anthropometric Measurements	BH	183.7	3.3	171.5	4.7	**0.000**
	BM	79.2	8.2	65.4	7.2	**0.000**
	PBF	12.5	2.7	20.4	4.3	**0.000**
	PSMM	44.8	5.0	37.5	4.1	**0.000**
	BMI	23.5	2.6	22.3	2.5	**0.000**
	PFI	3.8	1.1	1.9	0.5	**0.000**
Physical Abilities	Agility -	11.5	0.5	12.2	0.6	**0.003**
	Power	7703	470.5	6311	332	**0.000**
	Speed	3.2	0.2	3.5	0.2	**0.000**
Basketball-specific technical skills	Speed Spot Shooting (SS)	17.6	3.9	15.1	4.1	**0.000**
	Control Dribble/s (CD)	11.6	1.0	12.7	1.0	**0.000**
	Passing Score (PS)	22.8	3.0	20.3	2.9	**0.007**

A3. Gender-Based Differences in Centers (Table 6)

Table 6 summarizes gender comparisons across centers. Significant differences were again observed in nearly all anthropometric and physical variables ($p < .05$), with a few exceptions in technical outcomes.

Male centers were substantially taller (191.8 ± 4.2 cm vs 177.7 ± 5.5 cm, p = .000) and heavier (77.8 ± 9.2 kg vs. 63.4 ± 6.1 kg, p = .000) than female centers. They also exhibited lower body fat (12.4 ± 2.8% vs. 21.4 ± 3.3%, p = .000), higher skeletal muscle mass (44.1 ± 4.4 vs. 36.8 ± 3.5, p = .000), and higher protein-fat index (3.9 ± 1.2 vs. 1.8 ± 0.3, p = .000). Unlike the guard and forward positions, BMI differences were not statistically significant among centers (p = .081), suggesting relatively comparable body mass index values despite clear compositional differences.

Physically, male centers demonstrated superior agility (11.6 ± 0.5 s vs. 12.2 ± 0.5 s, p = .003), greater explosive power (7685.5 ± 376 vs 6173 ± 71, p = .000), and faster sprint speed (3.2 ± 0.2 s vs. 3.5 ± 0.2 s, p = .000).

Regarding technical skills, males scored significantly higher in shooting (17.8 ± 3.7 vs 16.1 ± 4.1, p = .007). They recorded faster dribbling times (11.3 ± 1.0 s vs 12.5 ± 1.0 s, p = .000). However, no significant gender difference was observed in passing performance (p = .160), indicating relative similarity between male and female centers in this skill.

Table 6. *Gender – based Significant differences of All Variables for (Center)Basketball Players*

Total Sample Characteristics		**All Sample (235)**				**p value**
		Males		**Females**		
		Mean	**SD**	**Mean**	**SD**	
Anthropometric Measurements	BH	191.8	4.2	177.7	5.5	**0.000**
	BM	77.8	9.2	63.4	6.1	**0.000**
	PBF	12.4	2.8	21.4	3.3	**0.000**
	PSMM	44.1	4.4	36.8	3.5	**0.000**
	BMI	21.2	2.7	20.0	2.3	0.081
	PFI	3.9	1.2	1.8	0.3	**0.000**
Physical Abilities	Agility	11.6	0.5	12.2	0.5	**0.003**
	Power	7685.5	376	6173	71	**0.000**
	Speed	3.2	0.2	3.5	0.2	**0.000**
Basketball-specific technical skills	Speed Spot Shooting (SS)	17.8	3.7	16.1	4.1	**0.007**
	Control Dribble/s (CD)	11.3	1.0	12.5	1.0	**0.000**
	Passing Score (PS)	22.5	2.6	21.2	2.0	0.160

Interpretation of Positional Differences

Across the three playing positions guards, forwards, and centers gender consistently emerged as a significant categorical variable influencing anthropometric characteristics and physical abilities. Male players exhibited greater stature, muscle mass, power, speed, and agility, as well as lower body fat percentages. Technical skill differences were apparent in shooting and dribbling across positions, while passing performance demonstrated smaller and less consistent gender differences, particularly among centers.

These findings collectively support Hypothesis 7, confirming that gender significantly influences the structural, functional, and partially technical performance profiles of Lebanese youth basketball players across playing positions.

5.2.2 Differences based on Playing position

A one-way multivariate analysis of variance (MANOVA) was conducted to examine whether anthropometric characteristics, physical abilities, and basketball-specific technical skills differed across playing positions (guards, forwards, and centers) in male and female Lebanese youth basketball players. The analysis tested the supplementary hypothesis (H8): that Playing Position is a categorical variable that significantly affects the relationships among Physical abilities, Anthropometric Characteristics, and key basketball-specific variables in Lebanese young basketball players. Results of these analyses are presented in Tables 7 and 8.

B1. Male Basketball Players

In the male sample ($n = 142$), MANOVA revealed a statistically significant multivariate effect of playing position on the combined dependent variables ($p < .001$), indicating overall differences across positions. Univariate analyses showed that body height ($F(2, 126.7) = 16.47$, $p < .001$, partial $\eta^2 = 0.646$) and body mass index (BMI) ($F(2, 126.7) = 17.981$, $p < .001$, partial $\eta^2 = 0.206$) differed significantly by playing position, with large and moderate effect sizes, respectively.

Scheffé post hoc comparisons indicated that centers were significantly taller than forwards (MD = 8.07 cm) and guards (MD = 14.92 cm), and forwards were taller than guards (MD = 6.85 cm); all pairwise comparisons for height were significant ($p < .001$). For BMI, centers had higher values than guards (MD = 3.65, $p < .001$) and forwards (MD = 2.28, $p < .001$), while no significant differences were observed between guards and forwards ($p = .056$).

No significant positional differences were observed for other anthropometric variables, including body mass, percentage body fat mass (PBFM), skeletal muscle mass (PSMM), and protein-fat index (PFI) (all $p > .05$, partial $\eta^2 \leq 0.007$). Similarly, no significant differences were found for physical performance measures such as power, speed, and agility (all p >

.05, partial $\eta^2 \leq 0.028$), or for technical skill measures including speed spot shooting (SS), control dribble (CD), and passing score (PS) (all $p > .05$, partial $\eta^2 \leq 0.018$).

These results indicate that, among male youth players, positional differences are primarily anthropometric. Taller and higher-BMI players tend to occupy the center position, whereas physical abilities and technical skills do not differ significantly by position.

B2. Female Basketball Players

For the female sample (n = 93), MANOVA also revealed a statistically significant multivariate effect of playing position ($p < .001$). Univariate analyses showed that body height ($F(2, 90) = 28.34$, $p < .001$, partial $\eta^2 = 0.386$) and BMI ($F(2, 90) = 10.40$, $p < .001$, partial $\eta^2 = 0.188$) significantly varied across positions, with effect sizes indicating a large impact for height and moderate impact for BMI.

Post hoc Scheffé comparisons confirmed that centers were taller and exhibited higher BMI than guards and forwards, mirroring the pattern observed in males. Conversely, no significant differences were found in body mass, PBFM, PSMM, PFI, physical performance variables (power, 20-m sprint speed, agility), or technical skills (SS, CD, PS) (all $p > .05$, partial $\eta^2 \leq 0.041$).

Overall, female players demonstrated structural positional differentiation similar to that of males, with anthropometric traits particularly height and BMI distinguishing positions. Physical performance and technical skill measures were not dependent on playing position.

5.2.3 Summary of Findings

Across both male and female Lebanese youth basketball players, playing position significantly influenced anthropometric characteristics, especially height and BMI, with centers generally taller and heavier relative to guards and forwards. However, no significant differences in body composition indices beyond BMI, physical fitness variables, or basketball-specific technical skills were observed. These findings indicate that positional differentiation in youth basketball is primarily structural rather than performance-based, highlighting the importance of anthropometric profiles in player role assignment at this developmental stage.

Based on these results, Hypothesis 7: "Playing Position is a categorical variable that significantly impacts the relationship between physical abilities, anthropometric characteristics, and key basketball-specific skills in Lebanese youth basketball players according to playing position" is partially supported. Selected anthropometric characteristics (height, BMI) influence playing position, whereas most other physical and body composition variables do not show significant influence.

Table 7. *MANOVA Differences in Playing Position among the three Groups of Male Basketball Players (n=142)*

Dependent Variable	Type Sum Squares	F	df	Mean Square	P value	Partial Eta Squared
BH	3972.946	126.7	2	1986.4	**0.000**	0.646
BM	72.713	0.523	2	36.357	0.594	0.007
PBFM	6.722	0.421	2	3.361	0.657	0.006
PSMM	16.589	0.369	2	8.294	0.692	0.005
BMI	249.631	17.981	2	124.815	**0.000**	0.206
PFI	0.722	0.287	2	0.361	0.751	0.004
Power	91670.796	0.229	2	45835	0.796	0.003
Speed 20m	0.176	1.970		0.0882	0.143	0.028
Agility	0.162	0.343	2	0.081	0.710	0.005
Speed Spot Shooting (SS)	1.804	0.062	2	0.902	0.940	0.001
Control Dribble/s (CD)	2.565	1.291	2	1.283	0.278	0.018
Passing Score (PS)	10.275	0.648	2	5.138	0.525	0.009

Note. Statistically Significant Difference were considered at $p < 0.05$

Table 8. *MANOVA Differences in Playing Position among the three Groups of Female Basketball Players (n=93)*

Dependent Variable	Type Sum Squares	F	df	Mean Square	P value	Partial Eta Squared
BH	1356.5	28.342	2	678.2	**0.000**	0.386
BM	7273.2	0.776	2	36.6	0.468	0.017
PBFM	15.258	0.487	2	7.629	0.616	0.011
PSMM	49.056	1.581	2	24.528	0.211	0.034
BMI	138.099	10.399	2	69.449	**0.000**	0.188
PFI	0.472	1.209	2	0.236	0.303	0.026
Power	454811	1.903	2	227405	0.155	0.041
Speed 20m	0.133	1.455	2	0.066	0.239	0.031
Agility	0.505	0.797	2	0.252	0.454	0.17
Speed Spot Shooting (SS)	25.687	0.803	2	12.843	0.451	0.018
Control Dribble/s (CD)	1.406	0.700	2	0.703	0.499	0.015
Passing Score (PS)	7.655	0.437	2	3.827	0.684	0.010

Note. Statistically Significant Difference were considered at $p < 0.05$

Relationships and Effects of Independent variables on the dependent variables

Pearson correlation (Table 9) and bivariate regression analysis (Table 10) were utilized to evaluate the following supplementary hypotheses:

- H1: Anthropometric characteristics (body height [BH], body weight [BW], body mass index [BMI], percentage body fat mass [PBFM], percentage skeletal muscle mass [PSMM], and physical fitness index [PFI]) significantly influence shooting performance among Lebanese youth basketball players by playing position.
- H2: Anthropometric characteristics (BH, BW, BMI, PBFM, PSMM, and PFI) significantly influence dribbling performance among Lebanese youth basketball players by playing positioH3: Anthropometric characteristics (BH, BW, BMI, PBFM, PSMM, and PFI) significantly influence passing performance among Lebanese youth basketball players by playing position.
- H4: Physical abilities (agility, power, and speed) significantly affect shooting performance in Lebanese young basketball players according to playing position.
- H5: Physical abilities (agility, power, and speed) significantly affect dribbling performance among Lebanese youth basketball players by playing position.
- H6: Physical abilities (agility, power, and speed) significantly affect passing performance among Lebanese youth basketball players by playing position.

C1. Relationships between Anthropometric characteristics, physical abilities, and basketball-specific skills

To examine the predictive relationships between anthropometric characteristics, physical abilities, and basketball-specific skills, Pearson correlation analyses (Table 6) were conducted for the combined male and female sample (N = 235). The analysis tested six supplementary hypotheses regarding the influence of anthropometric traits and physical abilities on shooting (SS), dribbling (CD), and passing (PS) performance.

Table 9. *Pearson Correlations Between all variables in Lebanese Youth Basketball Players (N = 235)*

		Agility	BMI	Height	Weight	PBFM	PFI	PSMM	Speed 20m	Power
SS	Pearson Correlation	**-.176****	0.128	**.183****	**.244****	**-.223****	**.166***	**0.128**	**-.248****	**.240****
	Sig. (2-tailed)	0.007	0.051	0.005	0.000	0.001	0.011	0.050	0.000	0.000
	N	235	235	235	235	235	235	235	235	235
CD	Pearson Correlation	**.273****	-0.048	**-.348****	**-.284****	**.351****	**-.351****	**-.333****	**.326****	**-.314****
	Sig. (2-tailed)	0.000	0.468	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	N	235	235	235	235	235	235	235	235	235
PS	Pearson Correlation	-0.092	0.100	**.182****	**.220****	-0.125	0.093	**.130***	-0.121	**.223****
	Sig. (2-tailed)	0.161	0.128	0.005	0.001	0.055	0.156	0.047	0.063	0.001
	N	235	235	235	235	235	235	235	235	235

Note. SS = Speed Spot Shooting; CD = Control Dribble; PS = Passing Score; BH = Body Height; BM = Body Mass; BMI = Body Mass Index; PBFM = Percentage Body Fat Mass; PSMM = Percentage Skeletal Muscle Mass; PFI = Protein-Fat Index. **p < .01, p < .05.

Shooting Performance (SS) – H1 & H4

Significant positive correlations were observed between body height (r = 0.183, p = .005), weight (r = 0.244, p < .001), and power (r = 0.240, p < .001) with shooting performance, indicating that taller, heavier, and more powerful players tended to perform better in speed spot shooting.

Negative correlations were found with agility (r = -0.176, p = .007), percentage body fat mass (PBFM) (r = -0.223, p = .001), and 20-m sprint speed (r = -0.248, p < .001), suggesting that lower body fat, faster sprint speed, and higher agility were associated with better shooting.

Other anthropometric variables (BMI, protein-fat index [PFI], and skeletal muscle mass [PSMM]) showed weak or non-significant associations (p > .05).

Interpretation: H1 and H4 are partially supported. Certain anthropometric measures (height, weight, PBFM) and physical abilities (power, agility, speed) significantly influence shooting performance, while others do not.

Dribbling Performance (CD) – H2 & H5

Positive correlations were observed with agility ($r = 0.273$, $p < .001$), PBFM ($r = 0.351$, $p < .001$), and 20-m sprint speed ($r = 0.326$, $p < .001$), indicating that more agile players with moderate body fat and faster sprint speed exhibited better dribbling control.

Negative correlations were found with height ($r = -0.348$, $p < .001$), weight ($r = -0.284$, $p < .001$), PFI ($r = -0.351$, $p < .001$), PSMM ($r = -0.333$, $p < .001$), and power ($r = -0.314$, $p < .001$), suggesting that taller, heavier, or more muscular players had slower or less controlled dribbling performance.

BMI was not significantly correlated with dribbling ($r = -0.048$, $p = .468$).

Interpretation: H2 and H5 are supported, indicating that both anthropometric characteristics (especially height, weight, PSMM, PFI, and PBFM) and physical abilities (agility, speed, power) significantly affect dribbling performance, although some relationships are inverse.

Passing Performance (PS) – H3 & H6

Significant positive correlations were found with body height ($r = 0.182$, $p = .005$), weight ($r = 0.220$, $p = .001$), and power ($r = 0.223$, $p = .001$), suggesting that taller, heavier, and more powerful players had better passing performance.

Other variables, including agility, BMI, PBFM, PSMM, PFI, and 20-m sprint speed, showed weak or non-significant correlations ($p > .05$).

Interpretation: H3 and H6 are partially supported, indicating that selected anthropometric characteristics (height, weight) and power influence passing performance, whereas most other physical and body composition variables do not show significant relationships.

C2. Effects of anthropometric characteristics and physical abilities on basketball-specific skills

Bivariate regression analyses presented in tables 6-7 were conducted to examine the predictive effects of anthropometric characteristics (BMI, PBFM, PSMM, and PFI) and physical abilities (agility, power, and 20-m sprint speed) on basketball-specific skills (Speed Spot Shooting [SS], Control Dribble [CD], and Passing Score [PS]) among Lebanese youth basketball players ($N = 235$). These analyses were performed to test hypotheses H1–H6.

Regarding the effect of anthropometric characteristics on shooting performance (H1), the regression model was statistically significant ($F = 4.085$, $p < .05$), explaining 5% of the variance (Adjusted $R^2 = .050$). Among the predictors, percentage body fat mass (PBFM) was the only significant variable ($\beta = -0.280$, $t = -2.537$, $p = .012$), indicating that higher body fat percentage was associated with lower shooting performance. BMI, percentage skeletal muscle mass (PSMM), and protein-fat index (PFI) did not significantly predict shooting ($p > .05$). Thus, H1 was partially supported.

For dribbling performance (H2), the anthropometric regression model was statistically significant ($F = 10.762$, $p < .05$) and accounted for 14.3% of the variance (Adjusted $R^2 = .143$). PBFM positively predicted dribbling ($\beta = 0.060$, $t = 2.067$, $p = .040$), while PSMM negatively predicted dribbling performance ($\beta = -0.046$, $t = -2.729$, $p = .007$). BMI and PFI were not significant predictors ($p > .05$). These findings indicate that body composition contributes to dribbling performance, although the effects vary in direction, leading to partial support for H2.

In contrast, the regression model examining passing performance (H3) was not statistically significant ($F = 2.149$, $p > .05$), explaining only 1.9% of the variance (Adjusted $R^2 = .019$). None of the anthropometric variables significantly predicted passing performance (all $p > .05$). Therefore, H3 was not supported.

Concerning the effect of physical abilities on shooting performance (H4), the regression model was statistically significant ($F = 7.774$, $p < .05$) and explained 8% of the variance (Adjusted $R^2 = .080$). Power positively predicted shooting performance ($\beta = 0.001$, $t = 2.034$, $p = .043$), whereas sprint speed negatively predicted shooting ($\beta = -2.702$, $t = -2.550$, $p = .011$). Agility did not significantly predict shooting performance ($p > .05$). Accordingly, H4 was partially supported.

For dribbling performance (H5), the physical abilities model was statistically significant ($F \approx 15.670$, $p < .001$), accounting for 15.8% of the variance (Adjusted $R^2 = .158$). All three predictors significantly contributed to the model: agility ($\beta = 0.289$, $t = 2.350$, $p = .020$), power ($\beta \approx -0.000$, $t = -2.548$, $p = .011$), and sprint speed ($\beta = 0.962$, $t = 3.419$, $p < .001$). These findings demonstrate that physical abilities strongly influence dribbling performance, and therefore, H5 was supported.

Finally, regarding passing performance (H6), the regression model was statistically significant overall ($F = 4.173$, $p < .05$), explaining 3.9% of the variance (Adjusted $R^2 = .039$). Power was the only significant predictor ($\beta = 0.001$, $t = 2.819$, $p = .005$), whereas agility and sprint speed were not significant ($p > .05$). Consequently, H6 was partially supported.

Overall, the regression analyses reveal that physical abilities explain a greater proportion of variance in basketball-specific skills than anthropometric characteristics. Dribbling performance was the most strongly predicted skill, particularly by agility and speed, while shooting performance was moderately influenced by body fat percentage and power. Passing performance demonstrated a limited association with anthropometric traits and was primarily predicted by power. However, the relatively modest R^2 values across models suggest that technical performance in youth basketball is multifactorial and influenced by additional tactical, cognitive, and training-related factors beyond anthropometry and physical fitness.

Table 10. *Bivariate Regression Analysis: effect of Anthropometric Characteristics on Basketball Specific Skills (n= 235)*

Hypothesis	Regression Weights	Beta Coefficient	Adjusted R2	T	F	P value	Hypothesis Supported
H1 Anthropometric Characteristics significantly affect Speed Spot Shooting	PBFM - SS	-0.280	0.050	-2.537	4.085	**0.012**	Partially Supported
	PSMM - SS	0.059	0.050	0.932	4.085	0.352	
	BMI - SS	0.120	0.050	1.344	4.085	0.180	
	PFI - SS	-0.683	0.050	-1.345	4.085	0.180	
H2 Anthropometric Characteristics significantly affect dribbling performance	PBFM - CD	0.060	0.143	2.067	10.762	**0.040**	Partially Supported
	PSMM - CD	-0.046	0.143	-2.729	10.762	**0.007**	
	BMI - CD	0.007	0.143	0.289	10.762	0.733	
	PFI -CD	0.040	0.143	0.302	10.762	0.763	
H3 Anthropometric Characteristics significantly affect passing performance.	PBFM - PS	-0.140	0.019	-1.701	2.149	0.090	Not Supported
	PSMM - PS	0.081	0.019	1.709	2.149	0.089	
	BMI - PS	0.069	0.019	1.045	2.149	0.297	
	PFI -PS	-0.521	0.019	-1.402	2.149	0.162	

SS: Speed Spot Shooting, CD: Control Dribble, PS: Passing Score
Table Processed through SPSS

Table 11. *Bivariate Regression Analysis: effect of Physical Abilities on Basketball Specific Skills (n= 235)*

Hypothesis	Regression Weights	Beta Coefficient	Adjusted R2	T	F	P value	Hypothesis Supported
H4 Physical Abilities significantly affect Speed Spot Shooting	Agility - SS	-0.536	0.080	-1.158	7.774	0.284	Partially Supported
	Power - SS	0.001	0.080	2.034	7.774	**0.043**	
	Speed - SS	-2.702	0.080	-2.550	7.774	**0.011**	
H5 Physical Abilities significantly affect Control Dribble	Agility - CD	0.289	0.158	2.350	15670	**0.020**	Supported
	Power- CD	-0.000	0.158	-2.548	15670	**0.011**	
	Speed - CD	0.962	0.158	3.419	15670	**0.000**	
H6 Physical Abilities significantly affect Passing Score.	Agility - PS	-0.022	0.039	-0.063	4.173	0.950	Partially Supported
	Power - PS	0.001	0.039	2.819	4.173	**0.005**	
	Speed - PS	-0.493	0.039	-0.623	4.173	0.534	

SS: Speed Spot Shooting, CD: Control Dribble, PS: Passing Score
Table Processed through SPSS

6 CHAPTER SIX: DISCUSSION AND CONCLUSION

6.1 Discussion

This study examined the connections between important physical and anthropometric characteristics, assessing their influence on basketball skills in Lebanese adolescent players, considering gender and playing position. The research primarily focused on how body composition affected key basketball skills, such as shooting accuracy, dribbling control, and passing efficiency. In addition, the roles of agility, explosive power, and sprint speed in developing and using these skills were analyzed. Statistical and multivariate analyses were used to examine the relationships between physical traits, fitness characteristics, and technical skill.

Differences in the impact of structural and functional variables on performance, as influenced by gender and playing position, were also investigated. The findings are intended to assist coaches in formulating position-specific training programs, thereby facilitating the technical skill and physical development of young basketball players.

The study was guided by its General Hypothesis (HG), which postulated that anthropometric characteristics and physical abilities are independent factors that statistically significantly affect the key basketball-specific skills: shooting, dribbling, and passing in Lebanese young basketball players according to gender and playing position. Seven supporting hypotheses were tested for the purpose of answering the general research hypothesis.

To improve comprehension of the findings, the study's results were assessed and validated before being compared and contrasted with earlier studies looking at comparable factors in young basketball players from different nations.

The study's findings indicated that the assessed contextual variables exhibited statistical parity between male and female Lebanese youth basketball players. The lack of significant age differences between the sexes is particularly significant, considering that biological development during adolescence significantly affects body composition, muscle mass, strength, speed, and power (Malina et al., 2004; Lloyd & Oliver, 2012).

To enhance the validity of performance comparisons and mitigate the impact of maturation differences, it is often recommended that age be considered in research involving young athletes (Vaeyens et al., 2008).

Most students lived in cities, with about 80% of them coming from urban areas. This is consistent with global trends, where access to clubs, competitive leagues, and training facilities is primarily concentrated in urban areas (Hoare, 2000; Vila et al., 2012). In cities, late adolescents often have more chances for coaching and competition, which helps them develop their technical and physical skills.

It is important to note that the vast majority of players—roughly 88–89%—were educated in private schools. Many Middle Eastern and Mediterranean countries offer private schools that support athletic development through organized sports programs and interscholastic competitions (Nikolaidis et al., 2014). Participation in school sports usually leads to more regular training and more chances to compete. Most of the athletes' parents had moderate to high levels of education, with about a third having university degrees. According to earlier research, young athletes who have parents with higher levels of education are more likely to start and continue playing sports. This difference likely arises from these parents' greater understanding of health and their access to better resources (Côté, 1999; Fredricks & Eccles, 2004). Because there were no differences in parental education between boys and girls, it's unlikely that socio-educational support had a different effect on the athletic development of males and females.

The parents of the athletes had similar basketball backgrounds. Research shows that as young athletes mature, their performance increasingly depends on formal instruction rather than a familial sports background, even though parents with sports experience can help children develop and cultivate athletic talent (Côté, 1999) (Vaeyens et al., 2008). Given their similar family histories, this study suggests that the ensuing performance differences between boys and girls are mainly due to physical and corporeal factors rather than familial influences. These findings align with global research on youth basketball, highlighting the importance of considering demographic and environmental factors when analyzing body measurements and performance (Vila et al., 2012; Nikolaidis et al., 2014).

Because the study groups had similar demographic characteristics, differences in their later performance could be more easily linked to biological or sport-specific traits, rather than social or environmental factors. In the case of Lebanese youth players, regardless of gender, all individual technical skills were essentially the same across different playing positions. However, physical attributes showed clear and consistent differences depending on the position played.

These patterns are generally consistent with the global literature, despite observed context-specific variations.

Anthropometric data showed the most noticeable differences in body height between the sexes. Forwards (183.7 ± 3.3 cm) and guards (176.8 ± 4.8 cm) were shorter than male centers (191.8 ± 4.2 cm). In contrast, female centers (177.7 ± 5.5 cm) were taller than both forwards and guards.

According to such a hierarchical framework, Cui et al. (2019) and Gryko et al. (2019) found that centers at both elite and juvenile levels have clear height and reach advantages. Because height has a major impact on rim protection, rebounding, and interior play, it is a crucial factor in determining early positional specialization.

Strangely, guards had the highest BMI and centers the lowest, with little variation in body mass across positions for either gender. According to studies conducted at the elite level, centers usually have more lean muscle, which results in a larger body mass (Nikolaidis et al., 2014). As adolescents mature and their training backgrounds diverge, differences in body mass across positions might diminish, particularly within developing or non-elite groups. The reduced BMI observed in this cohort can be attributed to the tendency for height to increase during adolescence, often preceding significant muscle development (Malina et al., 2004).

These physical characteristics are crucial for early positional specialization, especially for skills like rim defense and rebounding.

Body composition metrics, encompassing PBFM and PSMM, exhibited minimal inter-site disparity. Female athletes presented a skeletal muscle mass percentage approximating 37–39% and a body fat mass percentage around 20–21%. Conversely, male athletes demonstrated a greater skeletal muscle mass percentage (approximately 44–45%) and a reduced body fat mass percentage (roughly 12–13%). These observed sex-based differences align with findings from international studies (Ostojic et al., 2006; Nikolaidis et al., 2014), thereby suggesting that adolescent male athletes generally possess a higher lean mass and a lower fat mass. The limited variability observed within each sex implies that, unlike stature, body composition does not serve as a determinant for positional differentiation at this developmental stage. Furthermore, a more muscular physique was correlated with enhanced performance, as noted by Türkçapar (2021), potentially attributable to variations in training regimens or competitive exposure.

There was significant parity between the sexes and all positions in terms of physical characteristics, agility, vertical jump strength, and sprint speed. The agility times of guards, forwards, and centers were almost the same roughly 12.2 seconds for females and 11.6 seconds for males. Sprint speed and vertical leap power showed very slight, insignificant differences. These findings are in contrast to those of Ivanović et al. (2022) and Stanković et al. In their 2022 study, it was observed that forwards and centers demonstrated superior explosive power, whereas guards exhibited enhanced speed and agility. The subtle differences observed within this sample may be attributable to their training regimens, which emphasize general physical development rather than specialized conditioning. Players within junior systems, where early specialization is less prevalent, might display comparable neuromuscular characteristics. This viewpoint aligns with the approach of Lloyd and Oliver (2012), who emphasize holistic physical development in adolescence prior to the specialization in specific athletic roles. Furthermore, the physical performance data of Lebanese male athletes, as presented by Stanković et al. (2022), correspond with established international benchmarks (e.g., agility approximately 11.6 seconds; sprint time around 3.1–3.2 seconds), suggesting the presence of competitive physical standards notwithstanding contextual variations.

Conversely, female performance values were somewhat lower than those observed in other elite European cohorts, a difference likely stemming from variations in training exposure, competition level, and sports system infrastructure.

Technically speaking, both genders' performance in all three categories: speed spot shooting, control dribble, and passing score showed a great deal of consistency across positions. For example, while female shooting scores varied slightly (14.7–16.1), male shooting scores stayed relatively constant across positions (17.6–17.8). Passing and dribbling scores showed very little positional variation. Rather than structural features, the observed similarities can be explained by the dominance of training exposure, motor learning, and neuromuscular development on skill performance in adolescence (Karalejić et al., 2009; Vaeyens et al., 2008). This finding suggests that it might be premature to focus only on physical dimensions for early specialization. Developing skills gradually through balanced training is crucial for all occupations. This perspective aligns with global studies indicating that a player's reach, height, and wingspan are crucial for determining their position, as these attributes confer benefits in shot-blocking, rebounding, and scoring from close range (Cui et al., 2019; Gryko et al., 2019). Furthermore, the existing standardization corroborates the findings of Jakovljević et al. (2011), who showed that maturation and training exposure, rather than positional morphology alone, significantly influence technical performance during adolescence. However, studies by Carvalho et al. (2018) and Ziv and Lidor (2009) have found more significant skill disparities, with guards generally outperforming centers in ball-handling and perimeter skills.

The analysis of gender differences showed that male athletes had better physical and body characteristics than female athletes. These included greater height, more skeletal muscle, less body fat, better vertical jump power, faster sprint times, and slightly higher technical scores. These results corroborate previous studies (Ostojic et al., 2006; Ziv & Lidor, 2009; Sattler et al., 2015) that primarily use neuromuscular and structural factors to explain gender differences. The findings of Sattler et al. (2015) and Ben Abdelkrim et al. (2010), who suggested that perceptual-cognitive skills may lessen sex-based disparities in some technical competencies, are consistent with the decreased gender gap in passing scores. International studies indicate that height is the primary determinant of positional differentiation among Lebanese youth basketball players. The limited variance in body composition and athletic prowess across positions may stem from the uniformity of training regimens. Technical skills are essential across all positions, which encourages a broad developmental approach instead of focusing on early specialization. Gender differences reflect global patterns, especially regarding physical attributes and performance measures that highlight strength. Lebanese youth show less positional specialization compared to elite European and NBA players, particularly in technical and physical abilities. Distinct positional profiles are becoming more apparent within carefully structured elite systems. For example, guards usually exhibit greater speed and agility, while centers often display more strength and vertical leap (Ben Abdelkrim et al., 2010; Cengizel & Cengizel, 2022; Gryko et al., 2019). The similar profiles seen in this study may be due to differences in training infrastructure, competitive standards, and developmental philosophies that emphasize comprehensive skill development over early specialization, as suggested by Lloyd and Oliver (2012) and Vaeyens et al. (2008). These findings also furnish crucial contextual information, serving as a foundation for forthcoming inferential analyses that will explore the anticipated correlations between anthropometric, physical, and technical performance attributes.

Independent t-tests conducted on Lebanese youth basketball players indicated notable gender disparities across nearly all assessed body measurements, athletic abilities, and most technical proficiencies. These results support Hypothesis 7, demonstrating a significant influence of gender on the attributes that contribute to basketball success across all positions. Prior studies (Malina et al., 2004; Nikolaidis et al., 2014; Ziv & Lidor, 2009) suggest that biological, physiological, and developmental distinctions between male and female athletes during adolescence can impact athletic performance.

In comparison to female players, male players at all positions: guards, forwards, and centers showed higher height, weight, muscle mass, and lower body fat. This is consistent with earlier research showing that due to hormonal and developmental changes during puberty, teenage boys typically have larger body dimensions and increased lean mass (Malina et al., 2004; Nikolaidis et al., 2014). Increased testosterone levels during late adolescence help boys build muscle and bone, which can improve their basketball performance (Ben Abdelkrim et al., 2010). Research conducted in Europe and elsewhere indicates that male athletes typically exhibit greater height, weight, and muscularity than their female counterparts occupying similar positions (Gryko et al., 2019; Sattler et al., 2015). Furthermore, the findings of this study, which reveal a higher protein-fat index and a greater percentage of muscle mass in boys, corroborate the superior muscularity observed in male juvenile basketball players.

Male athletes consistently demonstrated superior agility, sprinting velocity, and explosive strength across all positions. Contemporary investigations within the field of sports science suggest that male athletes frequently possess greater muscle mass, a higher percentage of fast-twitch muscle fibers, and enhanced anaerobic power (Armstrong & McManus, 2011; Ziv & Lidor, 2009; Nikolaidis et al., 2014).

The better performance of men in this study might be explained by the importance of explosive strength and speed in basketball, which are crucial for fast breaks, defensive plays, and jumping. Further research on teenage basketball players revealed that males have better vertical leaps, faster sprints, and increased agility at different levels (Ben Abdelkrim et al., 2010; Sattler et al., 2015). The male players' physical dominance in this game is consistent with youth basketball trends around the world.

The investigation also revealed gender-based disparities in technical proficiencies, although these were less pronounced than the observed differences in physical attributes and body dimensions. Female players typically exhibited slower dribbling speeds, whereas male guards and forwards demonstrated superior shooting and passing abilities. The observed difference might be attributed to the strong connection between basketball skill performance and physical attributes. Previous studies suggest that abilities like dribbling and shooting precision often depend on factors such as speed, strength, and coordination (Gryko et al., 2019).

Male athletes often utilize greater force and speed, potentially enhancing their performance in technical skill assessments. It is essential to recognize the substantial influence of training exposure, tactical understanding, and motor learning processes on technical skills (Vaeyens et al., 2008). As a result, the differences in training intensity, competitive chances, and development paths between male and female basketball programs could contribute to the observed differences in technical performance between the genders.

In the centers, where no statistically significant differences were found, the passing performance didn't show consistent gender differences across all positions. This suggests that some basketball skills depend more on tactical awareness, cognitive abilities, and teamwork than on physical characteristics. Previous studies show that situational awareness and game intelligence are more strongly correlated with technical skills, such as passing and decision-making, than with physical abilities (Sampaio et al., 2010). It's possible that the tactical demands of this talent, rather than physiological factors, account for the lack of significant gender differences in passing across centers.

The consistency of gender differences across playing positions is another noteworthy finding. Across all positions, gender differences were consistently observed, regardless of the players' specific roles. Male athletes generally showed similar advantages in physical attributes and skill, regardless of whether they played as guards, forwards, or centers.

This suggests that even when players take on different roles, there are still physiological differences between genders. These findings align with prior research in youth basketball, which indicates that inherent biological disparities between male and female athletes persistently influence performance, irrespective of positional requirements (Ben Abdelkrim et al., 2010; Nikolaidis et al., 2014). Technical skill variations among young Lebanese basketball players are contingent upon specific game situations and are of a relatively modest magnitude. These observations underscore the intricate nature of basketball performance and the imperative of accounting for gender-specific developmental attributes when formulating youth training programs. In addition to providing equal chances for skill development and tactical training for male and female athletes, coaches and sports scientists should use gender-sensitive training methods. These methods should consider differences in physical development, strength, and potential for performance.

A one-way MANOVA, conducted separately for each gender, was used to assess how playing position affected the physical characteristics, physical abilities, and basketball-specific skills of Lebanese youth basketball players.

The results demonstrated a statistically significant multivariate effect of playing position for both male and female participants, implying that several of the variables under investigation displayed variance across guard, forward, and center positions. These observed differences suggested that, while physical attributes and technical proficiencies were largely consistent across positions, positional differentiation was primarily associated with anthropometric characteristics, specifically body height and BMI. Therefore, the data partially supported Hypothesis 8, illustrating that playing position has a more substantial impact on structural traits than on functional or technical performance indicators in young basketball players.

The MANOVA results showed significant differences in body height and BMI among male players, depending on their position. Centers were significantly taller than both forwards and guards. Additionally, forwards were taller than guards. Centers also had higher BMI values than players in other positions. According to Hoare (2000), Karalejić et al. (2009), Vila et al. (2012), Ben Abdelkrim et al. (2010), Sampaio et al. (2006). The results align with the usual positional structure in basketball. In this structure, taller players are usually assigned to positions near the basket, like center. This is because these positions require skills for rebounding, blocking shots, and scoring from close range (Sampaio et al., 2010). Additional research indicates that centers are the tallest athletes, followed by forwards and guards (Gryko et al., 2019; Ostojic et al., 2006). Height is considered a crucial determinant of position assignment in basketball because it enhances reaching ability, rebounding proficiency, and defensive capabilities near the basket. Athletes occupying interior positions generally exhibit a greater body mass relative to their height, a characteristic that corresponds with the elevated BMI observed in the present study (Nikolaidis et al., 2014). The increased BMI in the study's centers corroborates previous research, which has shown that athletes in interior positions typically possess a larger body mass in relation to their height, reflecting the physical demands of posture and contact play (Nikolaidis et al., 2014). Conversely, the analysis of different body composition metrics, including muscle mass, protein-fat index, and body fat percentage, revealed minimal variation across positions. This suggests that, at the youth level, players' overall body composition is relatively uniform, notwithstanding differences in height and size. Furthermore, research indicates that body size, rather than specific body composition, primarily differentiates positions in young basketball players, alongside strength and jumping ability (Sampaio et al., 2010).

Likewise, no significant disparities were observed in the basketball-specific technical proficiencies, such as shooting, dribbling, and passing, among male athletes across different playing positions. This finding implies that adolescent players might undergo comparable technical instruction irrespective of their assigned positions. Prior investigations into youth basketball have underscored the importance of cultivating a broad range of skills during the formative years, rather than restricting players to specific technical roles (Vaeyens et al., 2008). Consequently, the study's lack of technical specialization could indicate a developmental strategy that prioritizes the acquisition of a comprehensive skill set before the more defined assignment of positional responsibilities in subsequent competitive levels.

For female players, the MANOVA analysis revealed a pattern similar to that of the male players. Significant differences in body height and BMI were found based on position; specifically, centers were taller and had higher BMIs than guards and forwards. The notable height difference highlighted its importance in the positioning of young female athletes. These results are consistent with global research showing that centers are generally much taller than perimeter players (Nikolaidis et al., 2014; Ziv & Lidor, 2009).

Likewise, the female group demonstrated no statistically significant disparities in technical skills, physical performance metrics, or body composition characteristics. This study's findings imply that uniform physical and technical training should be implemented for all athletes, regardless of their assigned position, within the framework of youth basketball development.

Youth development programs frequently emphasize the cultivation of a diverse skill set and physical attributes to optimize athletes' long-term athletic potential (Lloyd & Oliver, 2012). Consequently, positional specialization may become more pronounced, particularly within elite or professional environments and during advanced phases of competitive progression.

The comparable outcomes observed in male and female subjects imply that the categorization of juvenile basketball players by position is largely determined by physical attributes, rather than performance metrics, especially within developmental leagues where training methodologies and strategic approaches are still in flux. These results align with existing literature on talent identification, which suggests that coaches frequently prioritize height when assigning playing positions in basketball (Vaeyens et al., 2008).

The MANOVA findings indicate that, within the cohort of Lebanese youth basketball players, playing position significantly influences anthropometric characteristics, specifically body height and BMI; conversely, most technical skills and physical attributes exhibit relative uniformity across positions. The data suggest that positional differentiation among these young athletes is predominantly structural in nature, rather than functional. Despite the absence of substantial disparities in technical and physical capabilities, shorter players tend to be assigned to perimeter positions, whereas taller athletes are typically positioned in interior roles, such as centers.

Conversely, roles within elite adult basketball are distinctly determined by physical characteristics, body dimensions, and tactical responsibilities (Sampaio et al., 2006; Sampaio et al., 2010; Ziv & Lidor, 2009). The observed similarities among the young athletes in this investigation illuminate their developmental trajectories, the training methodologies employed in youth programs, and the progressive evolution of positional specialization within Lebanese basketball. Consequently, these findings underscore the necessity of training regimens that emphasize comprehensive technical and physical development prior to the implementation of position-specific specialization.

Pearson correlation and bivariate regression analyses were utilized to examine the relationships between body measurements, athletic performance, and basketball-specific skills within a group of Lebanese youth basketball players. The central aim was to evaluate the impact of structural and functional characteristics on passing, dribbling, and shooting abilities. The findings indicate that, despite variations in the magnitude of these correlations across skill levels, technical performance in youth basketball exhibits a correlation with both physical and physiological factors.

The Pearson correlation study showed that how well someone shoots quickly is positively related to their height, body weight, and muscle strength. This finding aligns with previous research indicating that taller and stronger players tend to excel in speed-spot shooting exercises. Specifically, height and upper-body strength confer mechanical advantages in shooting, primarily through enhanced shooting stability and higher release points (Okazaki & Rodacki, 2012; Ziv & Lidor, 2009). Furthermore, a positive correlation exists between power and shooting performance, which is consistent with studies suggesting that explosive strength enhances shooting efficiency, particularly in dynamic scenarios that demand rapid force production. Explosive power significantly predicted both shooting and passing performance. Shooting stability and range are improved by lower-body power, which helps transmit force more effectively through the kinetic chain (Mikołajec et al., 2025).

Likewise, effective passing requires quick force production and the coordinated integration of the upper and lower body, especially when executing long-distance passes.

A negative correlation was observed between shot performance and sprint speed. This finding could suggest a biomechanical compromise between optimal linear velocity and the controlled deceleration necessary for accurate shooting. Furthermore, the differing neuromuscular demands of various technical skills are underscored by the observation that shooting accuracy is more influenced by trunk stability and precise motor control than by peak velocity.

A. Shooting Performance

Shooting performance exhibited a negative correlation with body fat percentage, sprint velocity, and agility. Specifically, body fat percentage detrimentally affected shooting ability; this observation aligns with the research of Ferioli et al. (2018), who suggested that elevated adiposity could compromise neuromuscular efficiency, balance, and movement economy. Shooting necessitates precise force transfer, fine motor coordination, and postural stability; increased fat mass may reduce mechanical efficiency and accuracy. Height and body mass exhibited a positive correlation with shooting and passing performance, likely attributable to increased release angles, leverage, and force application (Mikołajec et al., 2025). Nevertheless, the overall explained variance of the anthropometric parameters was modest, implying that technical ability in young athletes may not be solely dictated by structural attributes (Vila et al., 2012). Consequently, this study reinforces the idea that enhanced fine motor skill performance during developmental phases does not invariably result from increased size or strength. Regression analysis provided further elucidation of these relationships. The sole anthropometric predictor demonstrating statistical significance in relation to shooting performance was percentage body fat mass (PBFM), thereby suggesting that players exhibiting lower body fat percentages achieved superior performance. Within the physical abilities model, power exhibited a positive correlation with shooting performance, whereas sprint speed demonstrated a negative correlation. These observations imply that explosive power and body composition exert a minimal impact on the shooting proficiency of young basketball players. Furthermore, other factors, including shooting ability, coordination, and perceptual-motor control, may also be significant contributors, as evidenced by the limited explained variation (Adjusted R^2 =.050–.080) (Okazaki & Rodacki, 2012). Consequently, these findings propose that although anthropometric characteristics influence spatial organization, their direct effect on technical performance is less pronounced during adolescence.

B. Effectiveness of Dribbling (Control Dribble)

Dribbling performance exhibited the most robust associations with anthropometric and physical attributes when compared to the other two technical skills assessed. The premise that basketball dribbling demands rapid directional alterations and enhanced neuromuscular coordination is substantiated by Pearson correlations, which revealed a positive relationship between superior dribbling performance and heightened agility and sprint speed (Scanlan et al., 2012). This finding aligns with the work of Sattler et al. (2015) and Ziv and Lidor (2009), who emphasized the importance of neuromuscular coordination and change-of-direction speed for effective ball handling. Quick deceleration and reacceleration are essential components of agility performance when dribbling under defensive pressure. These statistics demonstrate how crucial speed and agility are when handling the ball, particularly during offensive transitions and under pressure from the defense. Significantly, height, body weight, skeletal muscle mass, and power were all negatively correlated with dribbling performance, indicating that shorter, lighter athletes had superior dribbling control. This pattern is consistent with positional tendencies in basketball, where guards who are typically lighter and shorter than interior players—often have better ball-handling skills (Ben Abdelkrim et al., 2010).The biomechanical advantage of less lower body inertia, which enables players with smaller bodies to move the ball more deftly during quick movements, may also be indicated by the inverse correlation with skeletal muscle mass.The regression analysis confirmed that physical abilities significantly influence dribbling performance. Among the models studied, the one focused on physical abilities explained the most variance (Adjusted R^2 = .158). Power showed a negative correlation with dribbling performance, while agility and sprint speed were positively correlated. The results are consistent with other studies that indicate speed, agility, and coordination have a greater impact on ball-handling effectiveness than peak strength (Scanlan et al., 2012). Additionally, anthropometric regression analysis revealed that skeletal muscle mass had a negative correlation with dribbling performance while body fat percentage had a positive correlation, highlighting the complex relationship between body composition and movement-related technical skills.

C. Passing Performance

In contrast to shooting and dribbling, passing performance exhibited less pronounced correlations with anthropometric and physical characteristics. The correlation analysis revealed minor positive associations between passing and body height, body weight, skeletal muscle mass, and power, suggesting that taller and stronger players might experience a marginal benefit in passing-related activities. The results align with studies that indicate larger bodies and stronger upper bodies improve the length and force of passes, particularly in fast-break situations (Gryko et al., 2019).Conversely, the majority of anthropometric and physical characteristics exhibited no substantial correlation with passing performance, suggesting that technical skill, decision-making, and perceptual-cognitive capabilities might be more critical determinants of passing proficiency than physical attributes in isolation. The minimal impact of physical traits on basketball passing could be attributed to the necessity of integrating visual perception, anticipation, and strategic understanding (Vaeyens et al., 2008). Perceptual-cognitive factors, including judgement, anticipation, and spatial cognition, may exert a more significant influence, as demonstrated by the diminished correlations between passing performance and anthropometric and physical variables (Vestberg et al., 2012). This observation underscores the complex interplay of factors influencing basketball performance, extending beyond mere physical characteristics. The regression analysis corroborated this interpretation. Body composition variables do not seem to be reliable predictors of passing performance in young basketball players, as the anthropometric regression model for passing performance lacked statistical significance. Conversely, power emerged as the sole significant predictor within the physical abilities model, demonstrating a modest yet significant predictive effect. This finding implies that overall passing effectiveness is largely contingent upon technical and tactical proficiencies, notwithstanding the potential for explosive strength to augment pass strength. Furthermore, the model's restricted explanatory power (Adjusted R^2 =.039) reinforces the notion that a range of factors beyond anthropometry and fundamental physical fitness contribute to passing performance.

Comprehensive Analysis

The findings from the correlation and regression analyses indicate that the impact of physical attributes and anthropometric measurements on basketball-specific proficiencies is significantly contingent upon the nature of the technical tasks. Dribbling performance exhibited the most robust correlation with physical characteristics, especially speed and agility, thereby underscoring the critical importance of dynamic movement skills in ball-handling maneuvers. Body composition and power had a moderate impact on shooting performance, but passing performance showed very little correlation with the variables under analysis. The findings indicate that technical proficiency is a product of multiple influences, shaped by the interplay of physical, anthropometric, technical, and cognitive elements, a conclusion that aligns with contemporary investigations into youth basketball performance (Gryko et al., 2019; Scanlan et al., 2012; Vaeyens et al., 2008). The limited explanatory power of the regression models implies that, although physical and anthropometric attributes exert an influence on skill execution, they only partially account for the complex developmental trajectory that underpins basketball aptitude. These results underscore the necessity of comprehensive training protocols that integrate the cultivation of technical and perceptual-cognitive proficiencies with physical conditioning for adolescent basketball players. Coaches are cautioned against exclusively prioritizing physical attributes when evaluating young athletes, given that technical execution during formative periods is shaped by a constellation of interconnected elements. From a practical standpoint, the findings equip coaches, sports scientists, and training staff with evidence-based insights to create tailored development programs that account for individual player profiles, gender differences, and positional demands. For example, male and female players, as well as guards, forwards, and centers, may require distinct emphasis on agility, speed, power, or skill-specific drills to optimize performance. Such targeted programming supports long-term athletic development (Lloyd & Oliver, 2012) by improving physical capacities, refining technical skills, and reducing injury risk, ultimately enhancing both individual performance and team outcomes.

Furthermore, the study addresses a critical gap in regional sports science by providing context-specific data on Lebanese youth basketball players. While existing research often focuses on European or North American populations, this study contributes empirical evidence from the Middle Eastern context, offering culturally and developmentally relevant insights. This regional perspective informs coaching strategies, talent identification, and program design in Lebanon, advancing basketball development at the national level.

In terms of talent identification, the study proposes a comprehensive evaluation model that integrates anthropometric, physical, and technical assessments to support objective, data-driven selection processes. By linking structural characteristics and functional abilities to performance outcomes, the model enhances coaches' capacity to identify potential talent early while ensuring balanced development across skills and positions. This approach aligns with modern long-term athlete development frameworks emphasizing holistic, evidence-based pathways from youth to elite levels (Vaeyens et al., 2008; Ziv & Lidor, 2009).

6.2 Conclusion

The findings indicated that body mass index and height exhibited positional variation; specifically, shorter and lighter athletes were generally assigned to guard positions, whereas taller and heavier athletes were typically positioned inside. However, skills like shooting, dribbling, and passing showed cross-positional similarities, suggesting that young athletes value skill development over positional specialization. Agility, sprint speed, and explosive power were among the physical characteristics that varied among players and were found to be important for basketball success. Pearson correlation analysis revealed significant relationships between anthropometric factors and basketball skill. Players with elevated body fat percentages, reduced sprint speeds, and compromised agility frequently experienced less favorable shooting results. Conversely, those possessing greater height, weight, and strength often exhibited enhanced shooting performance. Moreover, physical characteristics, especially agility and sprint speed, were significantly associated with dribbling proficiency; however, athletes of larger size or increased muscularity typically demonstrated diminished dribbling capabilities, implying a possible trade-off between size and swift movement. In contrast, only height, weight, muscle mass, and explosive power showed slight positive correlations with passing, which were less strong and less consistent. The predictive power of these variables was clarified through bivariate regression analysis. Specifically, shooting performance exhibited an inverse relationship with body fat percentage; moreover, the contributions of skeletal muscle mass and body fat to dribbling performance were deemed statistically insignificant. Anthropometric factors exhibited a limited capacity for prediction. Physical skills, however, proved to be more dependable indicators: explosive strength and sprint speed were strong predictors of shooting performance, while agility, sprint speed, and power significantly influenced dribbling performance. Explosive power emerged as the primary indicator of passing performance, with other physical attributes exerting minimal influence. Regression models accounted for a limited proportion of the variance, with dribbling demonstrating the strongest predictive capacity. This finding highlights the intricate nature of technical skill acquisition and suggests the probable influence of supplementary factors, including tactical understanding, perceptual-cognitive abilities, and prior training. The results were significantly influenced by gender and playing position. Although both boys and girls had similar technical skill levels, male players tended to be taller, heavier, and more muscular, and they demonstrated superior speed, power, and agility. Differences in physical characteristics were more noticeable than differences in skills, suggesting that a young basketball player's position is significantly influenced by their body type. These data provided varying degrees of corroboration for the study's hypotheses.

- H1: Partially Supported; while other anthropometric measurements were not effective, body fat mass percentage was a predictor of shooting performance.

- H2: Partially supported; dribbling performance is somewhat predicted by body composition traits.

- H3: Not supported; passing performance was not significantly predicted by anthropometric variables.
- H4: Partially supported; shooting was predicted by explosiveness and sprint speed but not by agility.
- H5: Supported; dribbling performance was strongly predicted by agility, sprint speed, and power.
- H6: Partially supported; sprint speed and agility were not significant predictors of passing, but explosive power was.
- H7: Supported; the relationship between anthropometric and physical traits and technical abilities was significantly influenced by gender.
- H8: Partially supported; the playing position had a more significant effect on body measurements and physical characteristics than on technical skills.

The significance of this study lies in its ability to advance understanding of how anthropometric characteristics and physical fitness influence basketball skill development in young Lebanese athletes, while accounting for both gender and playing position. By examining the interplay between body composition (e.g., height, body mass, body fat percentage, skeletal muscle mass percentage, and protein fat index), physical abilities (agility, power, and speed), and basketball-specific technical skills (shooting, dribbling, passing), the study provides a multidimensional perspective on performance determinants in youth basketball. This approach moves beyond isolated assessments, highlighting the interaction between structural, functional, and technical factors and offering a nuanced understanding of youth athlete development.

Finally, the implications of this research extend beyond Lebanon. The multidimensional framework and assessment methodology can be adapted to other regions seeking to enhance youth basketball performance through scientifically grounded practices. By bridging theoretical knowledge and applied training, the study contributes both to the academic literature and practical coaching methodologies, providing a scalable, evidence-informed model for nurturing youth basketball talent globally.

While this study provides valuable scientific insights into the factors influencing basketball performance in young Lebanese players, highlighting the interactions among body measurements, physical abilities, and technical skills across genders and playing positions, the cross-sectional design limits the ability to draw conclusions about developmental changes.

Finally, the subsequent recommendations are presented in consideration of the present findings:

- Considering that agility, sprint velocity, and explosive strength substantially influence dribbling and shooting efficacy, youth basketball training initiatives should incorporate physical conditioning alongside the refinement of technical skills.

- Prioritize Agility and Speed: Because these physical attributes are the primary indicators of dribbling proficiency in young basketball players, coaches should concentrate their training efforts on agility and multidirectional speed development.

- Coaches and trainers should assess body composition and suggest appropriate physical conditioning methods to enhance adolescents' athletic performance, given the negative correlation between body fat percentage and shooting proficiency.

- Explosive power in the lower body is crucial; it directly translates to better shooting and passing. Therefore, a regular regimen of plyometric and strength training is essential to cultivate this attribute.

- Multidimensional Talent Identification: Rather than depending solely on height or body size, talent identification programs should evaluate athletes using a combination of anthropometric characteristics, physical capabilities, and technical skill evaluations.

- To prevent early specialization, coaches should encourage the development of a wide range of basketball skills across all positions during the early stages of skill development. This is especially important because Lebanese youth players showed less clear position-based differences.

- Customized training plans are essential. To boost technical skills and overall performance, coaches need to develop training regimens that are specifically designed for each player's unique physical attributes.

- Comprehensive Player Development: To support long-term athlete advancement, youth development programs must place a high priority on basic movement skills, coordination, motor control, and technical proficiency.

- Future programs and training should consider possible gender differences in the technical and physical abilities of adolescent basketball players.

- Improvement of Performance Determinants in Future Research: To better understand basketball performance, future studies should incorporate additional factors such as strategic awareness, perceptual-cognitive skills, training experience, and cognitive components.

- Longitudinal Research Designs: Long-term studies are recommended to examine how anthropometric characteristics, physical capacities, and technical skills change over different stages of youth development.

- Cross-Cultural and Comparative Studies: More studies comparing young basketball players in different nations or competitive settings would provide insightful information about how training regimens and developmental frameworks affect players' performance.

- Establishment of National Basketball Databases: In Lebanese basketball, the creation of national databases for anthropometric, physical, and technical performance metrics may help with evidence-based talent identification and athlete development programs.

- Sports organizations and coaching programs should encourage the use of scientific research to guide training methods and development plans for young basketball players. A long-term study is needed to track how body measurements and physical abilities change as people mature and train.

- Also, technical assessments might not fully capture the tactical aspects of real games, because they are done in controlled settings.

- To create a more comprehensive performance model, future research should incorporate match-performance statistics, biomechanical assessments, and mental assessments. The results suggest that future studies should track players over time to evaluate their development, include additional measures of tactical understanding, cognitive skills, and training intensity, and improve coaching strategies and talent identification in Lebanese youth basketball.

REFERENCE LIST

Abdelkrim, N. B., Chaouachi, A., Chamari, K., Chtara, M., & Castagna, C. (2010). Positional role and competitive-level differences in elite-level men's basketball players. *Journal of Strength and Conditioning Research, 24*(5), 1346–1355. https://doi.org/10.1519/JSC.0b013e3181cf7510

Abu Taha, H., El-Saleh, M., & Rusu, L. (2023). Anthropometric measurements and their relationship with technical skills and physical performance in junior basketball players. *Discobolul - Physical Education, Sport & Kinetotherapy Journal, 62*(3), 208-223. https://discobolulunefs.ro/media/.pdf

Ackland, T. R., Lohman, T. G., Sundgot-Borgen, J., Maughan, R. J., Meyer, N. L., Stewart, A. D., & Müller, W. (2012). Current status of body composition assessment in sport. *Sports Medicine, 42*(3), 227–249. https://doi.org/10.2165/11597140-000000000-00000

Alejandro, V., Santiago, S., Gerardo, V. J., Carlos, M. J., & Vicente, G. T. (2015). Anthropometric Characteristics of Spanish Professional Basketball Players. *Journal of human kinetics*, *46*, 99–106. https://doi.org/10.1515/hukin-2015-0038

Alvar, B. A., Sell, K., & Deuster, P. A. (Eds.). (2017). *NSCA's essentials of tactical strength and conditioning*. Human Kinetics.

Anderson, G. S., & Plecas, D. B. (2000). Predicting shooting scores from physical performance data. *Policing: An International Journal, 23*(4), 525–537.

Armstrong, N., & McManus, A. M. (2011). Physiology of elite young male athletes. *Medicine and sport science*, *56*, 1–22. https://doi.org/10.1159/000320618

Association for Research, Professional Councils, American Alliance for Health, & Dance. (1984). *Technical manual, health related physical fitness*. American Alliance for Health, Physical Education, Recreation & Dance.

Attri, R. K. (2019). *The models of skill acquisition and expertise development: A quick reference of summaries*. Speed To Proficiency Research: S2Pro

Balciunas, M., Stonkus, S., Abrantes, C., & Sampaio, J. (2006). Long-term effects of different training modalities on power, speed, skill, and anaerobic capacity in young male basketball players. *Journal of Sports Science & Medicine, 5*(1), 163–170. https://pubmed.ncbi.nlm.nih.gov/24198694/

Bartlett, J. D., & Murray, A. (2025). An assessment of anthropometric and physical profiles of highly trained youth male and female basketball athletes: Implications for talent selection and development. *International Journal of Sports Science & Coaching*, *20*(3), 1037-1046. https://www.researchgate.net/publication/39082869

Behm, D. G., & Sale, D. G. (1993). Intended rather than actual movement velocity determines velocity-specific training response. *Journal of Applied Physiology, 74*(1), 359–368. https://doi.org/10.1152/jappl.1993.74.1.359

Ben Abdelkrim, N., Chaouachi, A., Chamari, K., Chtara, M., & Castagna, C. (2010). Positional role and competitive-level differences in elite male basketball players. *Journal of Strength and Conditioning Research, 24*(5), 1346–1355. https://doi.org/10.1519/JSC.0b013e3181cf7510

Ben Abdelkrim, N., El Fazaa, S., & El Ati, J. (2007). Time–motion analysis and physiological data of elite under-19-year-old basketball players during competition. *British Journal of Sports Medicine, 41*(2), 69–75. https://doi.org/10.1136/bjsm.2006.032318

Benjaminse, A., Otten, B., Gokeler, A., Diercks, R. L., & Lemmink, K. A. P. M. (2017). Motor learning strategies in basketball players and its implications for ACL injury prevention: a randomized controlled trial. *Knee surgery, sports traumatology, arthroscopy: official journal of the ESSKA*, *25*(8), 2365–2376. https://doi.org/10.1007/s00167-015-3727-0

Bompa, T. (2000). *Total training for young champions*. Human Kinetics.

Carter, J. E. L., Ackland, T. R., Kerr, D. A., & Stapff, A. B. (2005). Somatotype and size of elite female basketball players. *Journal of Sports Sciences, 23*(10), 1057–1063. https://doi.org/10.1080/02640410400023233

Carvalho, H. M., Gonçalves, C. E., Collins, D., & Paes, R. R. (2018). Growth, functional capacities and motivation for achievement and competitiveness in youth basketball: an interdisciplinary approach. *Journal of sports sciences*, *36*(7), 742–748. https://doi.org/10.1080/02640414.2017.1340654

Castagna, C., Impellizzeri, F. M., Rampinini, E., D'Ottavio, S., & Manzi, V. (2008). The Yo-Yo intermittent recovery test in basketball players. *Journal of Science and Medicine in Sport, 11*(2), 202–208. https://doi.org/10.1016/j.jsams.2007.02.013

Cengizel, E., & Cengizel, Ç. Ö. (2022). Comparison of physical and motoric characteristics by playing positions in basketball. *Gaziantep University Journal of Sport Science, 7*(4), 375–384. https://doi.org/10.31680/gaunjss.1173282

Ceniccola, G. D., Castro, M. G., Piovacari, S. M. F., Horie, L. M., Corrêa, F. G., Barrere, A. P. N., & Toledo, D. O. (2019). Current technologies in body composition assessment: advantages and disadvantages. *Nutrition (Burbank, Los Angeles County, Calif.)*, *62*, 25–31. https://doi.org/10.1016/j.nut.2018.11.028

Charles, L. E., Burchfiel, C. M., Violanti, J. M., Fekedulegn, D., Slaven, J. E., Browne, R. W., Hartley, T. A., & Andrew, M. E. (2008). Adiposity measures and oxidative stress among police officers. *Obesity*, *16*(11), 2489–2497. https://doi.org/10.1038/oby.2008.395

Côté, J. (1999). The influence of the family in the development of talent in sport. *The Sport Psychologist, 13*(4), 395–417. https://doi.org/10.1123/tsp.13.4.395

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approach* (4th ed.). SAGE Publications.

Crisafulli, A., Melis, F., Tocco, F., & Laconi, P. (2002). External mechanical work versus oxidative energy consumption ratio during a basketball field test. *Journal of sports medicine and physical fitness*, *42*(4), 409. https://pubmed.ncbi.nlm.nih.gov/12391434/

Cronin, J., McNair, P. J., & Marshall, R. N. (2003). Lunge performance and its determinants. *Journal of sports sciences*, *21*(1), 49–57. https://doi.org/10.1080/0264041031000070958

Cui, Y., Liu, F., Bao, D., Liu, H., Zhang, S., & Gómez, M. Á. (2019). Key anthropometric and physical determinants for different playing positions during National Basketball Association draft combine test. *Frontiers in Psychology, 10*, 2359. https://doi.org/10.3389/fpsyg.2019.02359

Davids, K., Button, C., & Bennett, S. (2008). *Dynamics of skill acquisition: A constraints-led approach*. Human kinetics.

Dawes, J. J., Orr, R. M., Siekaniec, C. L., Vanderwoude, A. A., & Pope, R. (2016). Associations between anthropometric characteristics and physical performance in male law enforcement officers: a retrospective cohort study. *Annals of occupational and environmental medicine*, *28*, 26. https://doi.org/10.1186/s40557-016-0112-5

De Oliveira, P., da Silva, F., de Souza Oliveira, R., Mendes, L., Netto, M., & Cândido, A. (2016). Association between fat mass index and fat-free mass index values and cardiovascular risk in adolescents. *Revista Paulista de Pediatria, 34*(1), 30–37. https://doi.org/10.1016/j.rppede.2015.06.003

Delextrat, A., & Cohen, D. (2009). Strength, power, speed, and agility of women basketball players according to playing position. *Journal of Strength and Conditioning Research, 23*(7), 1974–1981. https://doi.org/10.1519/JSC.0b013e3181b86a7e

Djordjević, A., Jakovljević, S., Pajić, Z., & Nikolić, A. (2016). Speed-strength abilities and morphological characteristics of basketball players aged 10 and 11. *Physical Culture/Fizička Kultura*, *70*(1), 46-54. https://www.academia.edu/91636706

Enoka, R. M. (1997). Neural adaptations with chronic physical activity. *Journal of Biomechanics, 30*(5), 447–455. https://doi.org/10.1016/S0021-9290(96)00170-4

Erčulj, F., & Supej, M. (2006). The impact of fatigue on jump shot height and accuracy over a longer shooting distance in basketball. *Ugdymas. Kūno kultūra. Sportas.*, *4*(63), 35-41. https://scispace.com/pdf/

Erčulj, F., Blas, M., & Bračič, M. (2010). Physical demands on young elite European female basketball players with special reference to speed, agility, explosive strength, and take-off power. *Journal of strength and conditioning research*, *24*(11), 2970–2978. https://doi.org/10.1519/JSC.0b013e3181e38107

Erčulj, F., Jakovljević, S., Todorović, G., & Mandić, R. S. (2024). Some basketball skills of players ages 12, 13 and 14 from three generations. *Kinesiologia Slovenica: scientific journal on sport*, *30*(3), 63-81. https://doi.org/10.52165/kinsi.30.3.63-81

Ericsson, K. A., Krampe, R. T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review, 100*(3), 363–406. https://doi.org/10.1037/0033-295X.100.3.363

Espasa-Labrador, J., Martínez-Rubio, C., García, F., Fort-Vanmeergaehe, A., Guarch, J., & Calleja-González, J. (2025). Exploring the Relationship Between Game Performance and Physical Demands in Youth Male Basketball Players. *Journal of functional morphology and kinesiology*, *10*(3), 293. https://doi.org/10.3390/jfmk10030293

Falk, B., Lidor, R., Lander, Y., & Lang, B. (2004). Talent identification and early development of elite water-polo players: A 2-year follow-up study. *Journal of Sports Sciences, 22*(4), 347–355. https://doi.org/10.1080/02640410310001641566

Ferioli, D., Rampinini, E., Bosio, A., La Torre, A., Azzolini, M., & Coutts, A. J. (2018). The physical profile of adult male basketball players: Differences between competitive levels and playing positions. *Journal of sports sciences*, *36*(22), 2567–2574. https://doi.org/10.1080/02640414.2018.1469241

Fitts, P. M., & Posner, M. I. (1967). *Human performance*. Brooks/Cole.

Fredricks, J. A., & Eccles, J. S. (2004). Parental Influences on Youth Involvement in Sports. In M. R. Weiss (Ed.), *Developmental sport and exercise psychology: A lifespan perspective* (pp. 145–164). Fitness Information Technology.

Gaggioli, A., Morganti, L., Mondoni, M., & Antonietti, A. (2013). Benefits of combined mental and physical training in learning a complex motor skill in basketball. *Psychology*, *4*(09), 1-6. https://www.researchgate.net/publication/257030029

Garcia-Gil, M., Torres-Unda, J., Esain, I., Duñabeitia, I., Gil, S. M., Gil, J., & Irazusta, J. (2018). Anthropometric Parameters, Age, and Agility as Performance Predictors in Elite Female Basketball Players. *Journal of strength and conditioning research*, *32*(6), 1723–1730. https://doi.org/10.1519/JSC.0000000000002043

Gómez, M. A., Lorenzo, A., Ibañez, S. J., & Sampaio, J. (2013). Ball possession effectiveness in men's and women's elite basketball according to situational variables in different game periods. *Journal of sports sciences*, *31*(14), 1578-1587. https://doi.org/10.1080/02640414.2013.792942

Gordon, A. M., Huxley, A. F., & Julian, F. J. (1966). The variation in isometric tension with sarcomere length in vertebrate muscle fibres. *The Journal of Physiology, 184*(1), 170–192. https://doi.org/10.1113/jphysiol.1966.sp007909

Gryko, K., Stastny, P., Kopiczko, A., Mikołajec, K., Pecha, O., & Perkowski, K. (2019). Can Anthropometric Variables and Maturation Predict the Playing Position in Youth Basketball Players? *Journal of human kinetics*, *69*, 109–123. https://doi.org/10.2478/hukin-2019-0005

Gutiérrez-Vargas, R., Pino-Ortega, J., Ugalde-Ramírez, J., Sánchez-Ureña, B., Blanco-Romero, L., Trejos-Montoya, J., Gutiérrez-Vargas, J., & Rojas-Valverde, D. (2021). Physical and physiological demands according to gender, playing positions, and match outcomes in youth basketball players. *Revista Internacional de Ciencias del Deporte. 67*(18), 1-14. https://doi.org/10.5232/ricyde2022.06701

Han, M., Gómez-Ruano, M. A., Calvo, A. L., & Calvo, J. L. (2023). Basketball talent identification: a systematic review and meta-analysis of the anthropometric, physiological and physical performance factors. *Frontiers in Sports and Active Living*, *5*, 1264872. https://doi.org/10.3389/fspor.2023.1264872

Harman, E. A., Rosenstein, M. T., Frykman, P. N., Rosenstein, R. M., & Kraemer, W. J. (1991). Estimation of human power output from vertical jump. *The Journal of Strength & Conditioning Research, 5*(3), 116–120. https://journals.lww.com/nsca-jscr/abstract/1991

Hawkins, J. R., Sharp, E. B., & Williams, S. M. (2015). Take a Page from Your Coach's Play Book: Teaching Technical and Tactical Skills in Athletic Training. *Athletic Training Education Journal*, *10*(3), 244-248. https://scholar.google.com/scholar

Hoare, D. G. (2000). Predicting success in junior elite basketball players: The contribution of anthropometric and physical attributes. *Journal of Science and Medicine in Sport, 3*(4), 391–405. https://doi.org/10.1016/S1440-2440(00)80006-7

Hodges, N., & Williams, A. M. M. (Eds.). (2012). *Skill acquisition in sport*. Taylor & Francis.

Hoffman, J. R., Epstein, S., Einbinder, M., & Weinstein, Y. (1999). The influence of aerobic capacity on anaerobic performance and recovery indices in basketball players. *The Journal of Strength & Conditioning Research*, *13*(4), 407-411. https://journals.lww.com/nsca-jscr/

Hu, F. (2008). *Obesity epidemiology*. Oxford University Press.

Ili´c, M., Pang, H., Vlaški, T., Gruji˘ci´c, M., & Novakovi´c, B. (2022). Motives and Barriers for Regular Physical Activity among Medical Students from the Western Balkans (South-East Europe Region). *International Journal of Environmental Research and Public Health, 19*, 1-21. https://pdfs.semanticscholar.org/ff1a/.pdf

InBody. (2018). *Body composition 101: The beginner's guide*. InBody USA. https://inbodyusa.com/blogs/inbodyblog/28828609

Ivanović, J., Kukić, F., Greco, G., Koropanovski, N., Jakovljević, S., & Dopsaj, M. (2022). Specific physical ability prediction in youth basketball players according to playing position. *International Journal of Environmental Research and Public Health, 19*(2), 977. https://doi.org/10.3390/ijerph19020977

Jakovljevic, S. T., Karalejic, M. S., Pajic, Z. B., Macura, M. M., & Erčulj, F. F. (2012). Speed and agility of 12- and 14-year-old elite male basketball players. *Journal of strength and conditioning research*, *26*(9), 2453–2459. https://doi.org/10.1519/JSC.0b013e31823f2b22

Jakovljević, S., Karalejić, M., Pajić, Z., Gardašević, B., & Mandić, R. (2011). Influence of anthropometric characteristics on speed abilities of 14 years old elite male basketball players. *Journal of Physical Education & Sport*, *11*(2), 221-225. https://efsupit.ro/images/stories/20.pdf

Janssen, I., Baumgartner, R. N., Ross, R., Rosenberg, I. H., & Roubenoff, R. (2004). Skeletal muscle cut-points associated with elevated physical disability risk in older men and women. *American Journal of Epidemiology, 159*(4), 413–421. https://doi.org/10.1093/aje/kwh058

Jelicic, M. (2024). *Development and evaluation of basketball-specific tests of conditioning capacities* [Doctoral dissertation, Lietuvos sporto universitetas].

Karalejić, M., Jakovljević, S., & Janković, N. (2009). Relationship between motoric capabilities and basketball skills in young players (13 to 14 yrs old). In *Proceedings of the International Scientific Conference „Theoretical, methodology and methodical aspects of physical education* (pp. 182-188). University of Belgrade: Faculty of Sport and Physical education. [in Serbian].

Karalejic, M., Jakovljevic, S., & Macura, M. (2011). Anthropometric characteristics and technical skills of 12- and 14-year-old basketball players. *The Journal of sports medicine and physical fitness*, *51*(1), 103–110. https://pubmed.ncbi.nlm.nih.gov/21297570/

Karjalainen, V. (2021). *Developing Endurance for Sport Performance in a Basketball Team* [Bachelor's Thesis, Haaga-Helia University of Applied Sciences]. https://www.theseus.fi/bitstream/

Kathy, M. (2007). *Coaching Basketball Technical and Tactical Skills*. Human Kinetics. https://books.google.com.ag/books

Kim, J. H., Kim, H. L., Battushig, B., & Yoo, J. Y. (2021). Relationship between socio-demographics, body composition, emotional state, and social support on metabolic syndrome risk among adults in rural Mongolia. *PLOS ONE*, 16(9), e0254141. https://doi.org/10.1371/journal.pone.0254141

Krause, J. V., & Nelson, C. (2019). *Basketball skills & drills*. Human Kinetics.

Kukić, F., & Dopsaj, M. (2017). Factorial analysis of body composition in Abu Dhabi policemen. *Bezbednost Beograd*, *59*(2), 5-26. https://www.researchgate.net/publication/321978162

Lago-Peñas, C., Casais, L., Dellal, A., Rey, E., & Domínguez, E. (2011). Anthropometric and physiological characteristics of young soccer players according to their playing positions: relevance for competition success. *The Journal of Strength & Conditioning Research*, *25*(12), 3358-3367. https://doi.org/10.1519/JSC.0b013e318216305d

Le Gall, F., Carling, C., Williams, M., & Reilly, T. (2010). Anthropometric and fitness characteristics of international, professional, and amateur male graduate soccer players from an elite youth academy. *Journal of Science and Medicine in Sport*, 13(1), 90–95. https://doi.org/10.1016/j.jsams.2008.07.004

Lieber, R. L., & Fridén, J. (2000). Functional and clinical significance of skeletal muscle architecture. *Muscle & Nerve*, 23(11), 1647–1666. https://doi.org/10.1002/1097-4598

Lloyd, R. S., & Oliver, J. L. (2012). The youth physical development model: A new approach to long-term athletic development. *Strength & Conditioning Journal, 34*(3), 61–72. https://doi.org/10.1519/SSC.0b013e31825760ea

Louridas, M. (2016). *Strategies to improve acquisition of technical skill in surgical residents: From screening technical ability at the time of selection to incorporating performance adjuncts during training* [Doctoral dissertation, University of Toronto]. https://utoronto.scholaris.ca/server/api/core/bitstreams/

Magill, R., & Anderson, D. I. (2010). *Motor learning and control*. McGraw-Hill Publishing.

Malina, R. M., Bouchard, C., & Bar-Or, O. (2004). *Growth, maturation, and physical activity* (2nd ed.). Human Kinetics.

Martinho, D. V., Clemente, F. M., Ángel-Gomez, M., Rebelo, A., Field, A., Santos, C. C., Gouveia, É. R., Afonso, J., & Sarmento, H. (2025). Physical, Physiological, Technical and Tactical Responses According to the Playing Position in Male Basketball: A Systematic Scoping Review. *Journal of human kinetics*, *96*(Spec Issue), 5–35. https://doi.org/10.5114/jhk/203326

Masanovic, B. (2018). Comparative study of anthropometric measurement and body composition between junior basketball and volleyball players from Serbian national league. *Sport Mont Journal,* *16*(3), 19-24. https://www.researchgate.net/publication/328108230

McGill, S. M., Andersen, J. T., & Horne, A. D. (2012). Predicting performance and injury resilience from movement quality and fitness scores in a basketball team over 2 years. *Journal of strength and conditioning research*, *26*(7), 1731–1739. https://doi.org/10.1519/JSC.0b013e3182576a76

McInnes, S. E., Carlson, J. S., Jones, C. J., & McKenna, M. J. (1995). The physiological load imposed on basketball players during competition. *Journal of Sports Sciences*, *13*(5), 387–397. https://doi.org/10.1080/02640419508732254

Mikołajec, K., Arede, J., & Gryko, K. (2025). Examining physical and technical performance among youth basketball national team development program players: a multidimensional approach. *Scientific reports*, *15*(1), 3722. https://doi.org/10.1038/s41598-025-87583-7

Moir, G., & Glaister, M. (2004). The reliability of accelerative sprint performance: Does starting position matter? *Journal of Human Movement Studies*, *47*, 183–191.

Montgomery, P. G. (2010). *The Performance and Physiological Demands of Basketball Competition and Training* [Doctoral dissertation, School of Physiotherapy and Exercise Science, Griffith University]. https://research-repository.griffith.edu.au/items/

Nassif, N., & Amara, M. (2018). Sport, policy and politics in Lebanon. In *Sport Policy in Small States* (pp. 135-148). Routledge.

Nigg, B. M., MacIntosh, B. R., & Mester, J. (2000). *Biomechanics and biology of movement*. Human Kinetics.

Nikolaidis, P. T., & Vassilios Karydis, N. (2011). Physique and body composition in soccer players across adolescence. *Asian journal of sports medicine*, *2*(2), 75–82. https://doi.org/10.5812/asjsm.34782

Nikolaidis, P., Calleja-González, J., & Padulo, J. (2014). The effect of age on positional differences in anthropometry, body composition, physique and anaerobic power of elite basketball players. *Sport Sciences for Health*, *10*(3), 225-233. https://doi.org/10.1007/s11332-014-0198-5

Nugroho, S. A., Soegiyanto, S., & Sugiharto, S. (2019). The Effect of Teaching Models and Motor Skill Levels on The Result of Basketball Learning Technique. *Journal of Physical Education and Sports*, *8*(1), 1-6.

Okazaki, V. H., & Rodacki, A. L. (2012). Increased distance of shooting on basketball jump shot. *Journal of Sports Science & Medicine*, *11*(2), 231–237. https://doi.org/10.52082/jssm.2012.231

Orner, M. M. (2009). *Employability skill acquisition of career and technical education students* [Doctoral dissertation, Duquesne University]. https://dsc.duq.edu/cgi/viewcontent.cgi

Ostojic, S. M., Mazic, S., & Dikic, N. (2006). Profiling in basketball: Physical and physiological characteristics of elite players. *Journal of Strength and Conditioning Research*, *20*(4), 740–744. https://doi.org/10.1519/R-15944.1

Özer, Ö. (2019). Investigation of Strength, Flexibility and Balance Parameters with Performance Dimension in Basketball Players. *Journal of Education and Learning*, *8*(5), 225-231. https://www.researchgate.net/publication/335962202

Pauole, K., Madole, K., Garhammer, J., Lacourse, M., & Rozenek, R. (2000). Reliability and validity of the T-test as a measure of agility, leg power, and leg speed in college-aged men and women. *Journal of Strength and Conditioning Research*, *14*(4), 443–450. https://journals.lww.com/nsca-jscr

Peltekova, I., & Ignatov, G. (2018). Establishment of the level of physical development and flexibility among students from different sport games-basketball and football. *Research in Kinesiology*, *46*(1-2), 19-22. https://scholar.google.com/citations?

Pescatello, L. S. (Ed.). (2014). *ACSM's guidelines for exercise testing and prescription*. Lippincott Williams & Wilkins.

Pihlainen, K., Santtila, M., Häkkinen, K., & Kyröläinen, H. (2018). Associations of physical fitness and body composition characteristics with simulated military task performance. *Journal of Strength and Conditioning Research*, *32*(4), 1089–1098. https://doi.org/10.1519/JSC.0000000000001921

Qualtrics Experience Management. (2021). *Determining sample size: How to make sure you get the correct sample size*. https://www.qualtrics.com/uk/experience-management/

Rinaldo, N., Toselli, S., Gualdi-Russo, E., Zedda, N., & Zaccagni, L. (2020). Effects of anthropometric growth and basketball experience on physical performance in pre-adolescent male players. *International Journal of Environmental Research and Public Health*, 17(7), 2196. https://doi.org/10.3390/ijerph17072196

Rocha, J., Serrano, J., López-Sierra, P., & Ibáñez, S. J. (2025). Profiling External Load in U14 Basketball: Cluster Analysis of Competition Performance Using Inertial Devices. *Applied Sciences*, *15*(15), 8616. https://doi.org/10.3390/app15158616

Sampaio, J., Drinkwater, E. J., & Leite, N. M. (2010). Effects of season period, team quality, and playing position on basketball players' game-related statistics. *European Journal of Sport Science, 10*(2), 141–149. https://doi.org/10.1080/17461390903311935

Sampaio, J., Janeira, M., Ibáñez, S., & Lorenzo, A. (2006). Discriminant analysis of game-related statistics between basketball guards, forwards and centres in three professional leagues. *European Journal of Sport Science, 6*(3), 173–178. https://doi.org/10.1080/17461390600676200

Sattler, T., Sekulić, D., Spasić, M., Perić, M., Krolo, A., Uljević, O., & Kondrič, M. (2015). Analysis of the Association Between Motor and Anthropometric Variables with Change of Direction Speed and Reactive Agility Performance. *Journal of human kinetics*, *47*, 137–145. https://doi.org/10.1515/hukin-2015-0069

Scanlan, A. T., Dascombe, B. J., Reaburn, P., & Dalbo, V. J. (2012). The physiological and activity demands experienced by Australian female basketball players during competition. *Journal of science and medicine in sport*, *15*(4), 341-347. https://doi.org/10.1016/j.jsams.2013.05.008

Schmidt, R. A., & Lee, T. D. (2025). *Motor learning and performance: From principles to application*. Human Kinetics.

Schmidt, R. A., Lee, T. D., Winstein, C., Wulf, G., & Zelaznik, H. N. (2018). *Motor control and learning: A behavioral emphasis*. Human kinetics.

Sheppard, J. M., & Young, W. B. (2006). Agility literature review: Classifications, training and testing. *Journal of Sports Sciences*, 24(9), 919–932. https://doi.org/10.1080/02640410500457109

Sodaitis, B. (2020). Relation between anthropometric, physical, technical testing and game-related statistics in youth basketball players [Doctoral dissertation, Lithuanian Sports University]. https://vb.lsu.lt/object/elaba:61431276/

Stanković, A., Đorđević-Nikić, M., Kukić, F., Petrović, M., Cvijanović, N., & Todorović, N. (2013). The effect of strength training on the testosterone level in men. *Fizička Kultura*, 67(2), 157–166. https://www.researchgate.net/publication/293581734

Stanković, D., & Цанкова-Калоянова, M. (2018). *Relation of power, speed and agility in basketball players by position*. https://www.researchgate.net/publication/363335472

Stanković, M., Lazić, A., Milenković, D., Nurkić, F., & Kocic, M. (2022). Motoric Abilities of Basketball Players According to Different Ranks of Competition and Playing Positions. *Sport Mont Journal*, *20*(2), 11-16. https://www.researchgate.net/publication/362114643

Staron, R. S., Leonardi, M. J., Karapondo, D. L., Malicky, E. S., Falkel, J. E., Hagerman, F. C., & Hikida, R. S. (1991). Strength and skeletal muscle adaptations in heavy-resistance-trained women after detraining and retraining. *Journal of applied physiology*, *70*(2), 631–640. https://doi.org/10.1152/jappl.1991.70.2.631

Stevens, J., Cai, J., Pamuk, E. R., Williamson, D. F., Thun, M. J., & Wood, J. L. (1998). The effect of age on the association between body-mass index and mortality. *The New England journal of medicine*, *338*(1), 1–7. https://doi.org/10.1056/NEJM199801013380101

Stojanović, E., Stojiljković, N., Scanlan, A. T., Dalbo, V. J., & Milanović, Z. (2018). The activity demands and physiological responses encountered during basketball match-play: A systematic review. *Sports Medicine*, *48*(1), 111–135. https://doi.org/10.1007/s40279-017-0794-z

Susanto, N., García-Jiménez, J. V., Nowak, A. M., Setyawan, H., Pavlovic, R., Rusdiawan, A., & Syaukani, A. A. (2024). Development Assessment Model for Talent Identification of Young Indonesian Basketball Players: Anthropometrics, Biomotor, Technical, and Tactical Skills. *International Journal of Human Movement and Sports Sciences*, *12*(4), 625-635. https://doi.org/10.13189/saj.2024.120403

Torres-Unda, J., Zarrazquin, I., Gil, J., Ruiz, F., Irazusta, A., Kortajarena, M., Seco, J., & Irazusta, J. (2013). Anthropometric, physiological and maturational characteristics in selected elite and non-elite male adolescent basketball players. *Journal of sports sciences*, *31*(2), 196–203. https://doi.org/10.1080/02640414.2012.725133

Trninic, S., & Dizdar, D. (2000). System of the performance evaluation criteria weighted per positions in the basketball game. *Collegium antropologicum*, *24*(1), 217–234. https://pubmed.ncbi.nlm.nih.gov/10895549/

Türkçapar, Ü. (2021). *The Effect of Anthropometric Characteristics and Somatotypes of Basketball Players on their Basketball Skills*. https://pjmhsonline. com/index. php? route= product/product&path= 16655_16673_16677&product_id= 10660

Vaeyens, R., Lenoir, M., Williams, A. M., & Philippaerts, R. M. (2008). Talent identification and development programmes in sport: Current models and future directions. *Sports Medicine*, *38*(9), 703–714. https://doi.org/10.2165/00007256-200838090-00001

Vescovi, J. D., & McGuigan, M. R. (2008). Relationships between sprinting, agility, and jump ability in female athletes. *Journal of sports sciences*, *26*(1), 97–107. https://doi.org/10.1080/02640410701348644

Vestberg, T., Gustafson, R., Maurex, L., Ingvar, M., & Petrovic, P. (2012). Executive functions predict the success of top-soccer players. *PloS one*, *7*(4), e34731. https://doi.org/10.1371/journal.pone.0034731

Vickers, J. N. (2007). *Perception, cognition, and decision training: The quiet eye in action*. Human Kinetics.

Vila, H., Manchado, C., Rodriguez, N., Abraldes, J. A., Alcaraz, P. E., & Ferragut, C. (2012). Anthropometric profile, vertical jump, and throwing velocity in elite female handball players by playing positions. *Journal of strength and conditioning research*, *26*(8), 2146–2155. https://doi.org/10.1519/JSC.0b013e31823b0a46

Wang, J., Liu, W., & Moffit, J. (2010). What Skills and Tactics Are Needed to Play Adult Pick-Up Basketball Games? *The ICHPER.SD Journal of Research*, *5*(2), 41-47. https://www.researchgate.net/publication/348608022

Wang, Z. M., Pierson, R. N., Jr, & Heymsfield, S. B. (1992). The five-level model: a new approach to organizing body-composition research. *The American journal of clinical nutrition*, *56*(1), 19–28. https://doi.org/10.1093/ajcn/56.1.19

Willardson J. M. (2007). Core stability training: applications to sports conditioning programs. *Journal of strength and conditioning research*, *21*(3), 979–985. https://doi.org/10.1519/R-20255.1

Williams, A. M., & Reilly, T. (2000). Talent identification and development in soccer. *Journal of Sports Sciences*, 18(9), 657–667. https://doi.org/10.1080/02640410050120041

Wilmore, J. H., Costill, D. L., & Kenney, W. L. (2004). *Physiology of sport and exercise* (Vol. 20). Champaign, IL: Human kinetics.

Winter, E. M., Bromley, P. D., Davison, R., Jones, A. M., & Mercer, T. H. (2006). *Sport and Exercise Physiology Testing Guidelines: Volume I - Sport testing*. Routledge.

World Medical Association (2013). World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA*, *310*(20), 2191–2194. https://doi.org/10.1001/jama.2013.281053

Young, W. B., Dawson, B., & Henry, G. J. (2015). Agility and change-of-direction speed are independent skills: Implications for training for agility in invasion sports. *International Journal of Sports Science & Coaching*, *10*(1), 159-169.

Zatsiorsky, V. M., Kraemer, W. J., & Fry, A. C. (2020). *Science and practice of strength training*. Human kinetics.

Ziv, G., & Lidor, R. (2009). Physical attributes, physiological characteristics, on-court performances and nutritional strategies of female and male basketball players. *Sports medicine*, *39*(7), 547-568. https://doi.org/10.2165/00007256-200939070-00003

APPENDICES

Appendix 1: Lebanese Basketball clubs and Academies

Our Research Sample	
Academy	**Name of the Academy Director**
Blue Stars Academy	*Mr. Nadim Abboud*
Riyadi Academy	*Mr. Mazen Tabbarah*
Hoops Academy	*Mr. Jassem Kanso*
NSA Academy	*Mr. Nadim Souaid*
Dynamo Academy	*Mr. Faisal Kalaawi*
M13 Academy	*Mr. Elie Mchantaf*
Energy Academy	*Mr. Ghazi Boustany*
Extra Time Academy	*Mr. Mahmoud Harb*
Chabibeh Academy	*Mr. Fadi Tabet*
Sagesse Academy	*Mr. Elie Yahchouchi*
Brainers Academy	*Ralf Akl*
Kahraba Academy	*Saba Makhlouf*

Appendix 2: Copy of the Ethical Approval Given by Faculty of Sport and Physical Education, University of Belgrade

УНИВЕРЗИТЕТ У БЕОГРАДУ
ФАКУЛТЕТ СПОРТА И ФИЗИЧКОГ ВАСПИТАЊА
БЕОГРАД
Примљено: 7. 11. 2025.

Орг.јед.	Број	Прилог	Вредност
02	1067/25	12	

УНИВЕРЗИТЕТ У БЕОГРАДУ

Адреса: Студентски трг 1, 11000 Београд, Република Србија
Тел.: 011 3207400; Факс: 011 2638818; E-mail: kabinet@rect.bg.ac.rs

ВЕЋЕ НАУЧНИХ ОБЛАСТИ ДРУШТВЕНО-ХУМАНИСТИЧКИХ НАУКА

Београд, 28. oктобар 2025. године
02-02 Број: 61206-3315/4-25
МЦ

На основу члана 48 став 5 тачка. 3 Статута Универзитета у Београду („Гласник Универзитета у Београду", бр. 201/18, 207/19, 213/20, 214/20, 217/20, 230/21, 232/22, 233/22, 236/22, 241/22, 243/22, 244/23, 245/23, 247/23, 251/23, 258/24, 260/25 и 262/25) и члана 32 Правилника о докторским студијама на Универзитету у Београду („Гласник Универзитета у Београду", бр. 191/2016, 212/2019, 215/2020, 217/2020, 228/21, 230/21, 241/22 и 259/24), а на захтев Факултета спорта и физичког васпитања бр. 02-1067/25-10 од 10. oктобра 2025. године, Веће научних области друштвено-хуманистичких наука, на електронској седници одржаној 28. октобра 2025. године, донело је

О Д Л У К У

ДАЈЕ СЕ САГЛАСНОСТ на одлуку Наставно-научног већа Факултета спорта и физичког васпитања о прихватању теме докторске дисертације МАЗЕНА АЗИЈА (Mazen Azzi), под називом: „Associations between anthropometric characteristics, motor abilities and technical skill development in Lebanese youth basketball: a cross-positional study" („Релације између антропометријских карактеристика, моторичких способности и развоја техничких вештина у либанској омладинској кошарци: студија пресека") и одређивању проф. др Саше Јаковљевића за ментора.

П Р Е Д С Е Д Н И Ц А В Е Ћ А

проф. др Ивана Спасић

Доставити:
- Факултету
- архиви Универзитета

Appendix 3: Published Paper 1

IJKSS
Awareness in Health

International Journal of Kinesiology & Sports Science
ISSN: 2202-946X
www.ijkss.aiac.org.au

Positional Differences in Anthropometric Characteristics and Technical Skills Among Youth Basketball Players

Mazen Azzi*, Sasa Jakovljevic

University of Belgrade, Faculty of Sport and Physical Education, Blagoja Parovica 156, 11030, Belgrade, Serbia

Corresponding Author: Mazen Azzi, E-mail: azzimazen@gmail.com

ARTICLE INFO

Article history
Received: November 05, 2025
Revised: December 11, 2025
Accepted: January 05, 2026
Published: January 30, 2026
Volume: 14 Issue: 1

Conflicts of interest: None
Funding: None

ABSTRACT

Background: Youth basketball participation is rising globally, prompting evidence-based approaches to talent development, with performance shaped by technical skills, anthropometry, physiology, coordination, and structured assessment of growth and maturation. **Objectives:** This study examines the positional variations in Anthropometric traits and technical abilities unique to basketball among Lebanese youth basketball players aged 16–18 years. **Methods:** In this cross-sectional study, three positional groups, guards, forwards, and centers, were determined among 142 male players who were between the ages of 16 and 18. Body height, body mass, body fat percentage, and skeletal muscle mass were anthropometric variables, and spot shooting, control dribble, and passing accuracy tests were used to evaluate technical performance. To ascertain positional differences among the combined dependent variables, a one-way multivariate analysis of variance (MANOVA) was used. **Results:** Results revealed a statistically significant multivariate effect of playing position on the combined measures ($p < 0.001$). However, follow-up univariate analyses indicated that only body height differed significantly across positions ($p < 0.001$), with centers being markedly taller than forwards and guards. No significant positional variations were found for Anthropometric traits and technical abilities unique to basketball. **Conclusion:** These results imply that anthropometric, rather than skill-based, factors predominate in positional distinction among young basketball players in Lebanon. The findings demonstrate the early importance of physical characteristics, especially height, in defining positional responsibilities, even when technical ability competency is largely constant across playing positions. It is recommended that before moving on to position-specific specialization, coaches and talent developers priorities comprehensive, multiskilled training methods.

Key words: Anthropometry, Physical Fitness, Basketball, Sports Performance, Adolescent, Motor Skills.

INTRODUCTION

Among the most popular team sports worldwide is basketball., with youth participation steadily increasing in recent years (Sodaitis, 2020). The demand for evidence-based strategies for long-term player development and talent identification has increased as a result of this expansion (Hadzic et al., 2012). The focus of contemporary study has shifted from identifying "talent" early on to comprehending the developmental processes that lead to competence, emphasizing the intricate interactions between biological, technological, and physical elements in performance (Falk et al., 2004).

Shooting accuracy, dribbling, and passing precision are key determinants of basketball performance (Ziv & Lidor, 2009). Their acquisition depends not only on deliberate practice, tactical knowledge, and coaching strategies but also on athletes' anthropometric and physiological traits, which influence movement efficiency and neuromuscular coordination (Drinkwater et al., 2008). Standardized testing systems, have long assessed how body proportionality, coordination, and maturation impact skill development (Borukova, 2020; Apostolidis & Emmanouil, 2015).

Anthropometric characteristics including height, body mass, skeletal muscle percentage, and body fat percentage substantially shape performance potential. Greater muscle mass enhances explosive power, supporting passing, shooting, and rebounding, whereas excess fat can impair technical efficiency, speed, and endurance during high-intensity play (Hoare, 2000; Nikolaidis et al., 2015). Performance and training adaptations in youth are closely associated with body composition, whether measured by bioimpedance or manual anthropometry (Zarić et al., 2020; Ivanovic et al., 2022). Yet, few studies have specifically discovered how body composition variations influence basketball-specific technical skills, as most research focuses on general motor abilities such as agility, running, and jumping (Carvajal et al., 2012; Ramos et al., 2019).

Published by Australian International Academic Centre PTY.LTD.

http://dx.doi.org/10.7575/aiac.ijkss.v.14n.1p.76

Appendix 4: Copyright Statement Form

образац изјаве о ауторству

Изјава о ауторству

Име и презиме аутора Mazen Georges Azzi

Број индекса 5011/2022

Изјављујем

да је докторска дисертација под насловом

Associations Between Anthropometric Characteristics, Motor Abilities and Technical Skill Development in Lebanese Youth Basketball: A Cross-Positional Study

- резултат сопственог истраживачког рада;
- да дисертација у целини ни у деловима није била предложена за стицање друге дипломе према студијским програмима других високошколских установа;
- да су резултати коректно наведени и
- да нисам кршио/ла ауторска права и користио/ла интелектуалну својину других лица.

Потпис аутора

У Београду, 21/3/2026

Mazen Azzi

Appendix 5: Statement on the identity of the printed and electronic versions of the doctoral thesis

образац изјаве о истоветности штампане и електронске верзије докторског рада

Изјава о истоветности штампане и електронске верзије докторског рада

Име и презиме аутора Mazen Georges Azzi

Број индекса 5011/2022

Студијски програм Doctoral academic

Наслов рада

Associations Between Anthropometric Characteristics, Motor Abilities and Technical Skill Development in Lebanese Youth Basketball: A Cross-Positional Study

Ментор Professor Jakovljevic

Изјављујем да је штампана верзија мог докторског рада истоветна електронској верзији коју сам предао/ла ради похрањивања у **Дигиталном репозиторијуму Универзитета у Београду.**

Дозвољавам да се објаве моји лични подаци везани за добијање академског назива доктора наука, као што су име и презиме, година и место рођења и датум одбране рада.

Ови лични подаци могу се објавити на мрежним страницама дигиталне библиотеке, у електронском каталогу и у публикацијама Универзитета у Београду.

Потпис аутора

У Београду, 21/3/2026

Mazen Azzi

Appendix 6: Statement of use

образац изјаве о коришћењу

Изјава о коришћењу

Овлашћујем Универзитетску библиотеку „Светозар Марковић" да у Дигитални репозиторијум Универзитета у Београду унесе моју докторску дисертацију под насловом:

Associations Between Anthropometric Characteristics, Motor Abilities and Technical Skill Development in Lebanese Youth Basketball: A Cross-Positional Study

која је моје ауторско дело.

Дисертацију са свим прилозима предао/ла сам у електронском формату погодном за трајно архивирање.

Моју докторску дисертацију похрањену у Дигиталном репозиторијуму Универзитета у Београду и доступну у отвореном приступу могу да користе сви који поштују одредбе садржане у одабраном типу лиценце Креативне заједнице (Creative Commons) за коју сам се одлучио/ла.

1. Ауторство (CC BY)

2. Ауторство – некомерцијално (CC BY-NC)

3. Ауторство – некомерцијално – без прерада (CC BY-NC-ND)

4. Ауторство – некомерцијално – делити под истим условима (CC BY-NC-SA)

5. Ауторство – без прерада (CC BY-ND)

6. Ауторство – делити под истим условима (CC BY-SA)

(Молимо да заокружите само једну од шест понуђених лиценци.

Кратак опис лиценци је саставни део ове изјаве).

Потпис аутора

У Београду, 21/3/2026

Mazen Atti

1. **Ауторство**. Дозвољавате умножавање, дистрибуцију и јавно саопштавање дела, и прераде, ако се наведе име аутора на начин одређен од стране аутора или даваоца лиценце, чак и у комерцијалне сврхе. Ово је најслободнија од свих лиценци.

2. **Ауторство – некомерцијално**. Дозвољавате умножавање, дистрибуцију и јавно саопштавање дела, и прераде, ако се наведе име аутора на начин одређен од стране аутора или даваоца лиценце. Ова лиценца не дозвољава комерцијалну употребу дела.

3. **Ауторство – некомерцијално – без прерада**. Дозвољавате умножавање, дистрибуцију и јавно саопштавање дела, без промена, преобликовања или употребе дела у свом делу, ако се наведе име аутора на начин одређен од стране аутора или даваоца лиценце. Ова лиценца не дозвољава комерцијалну употребу дела. У односу на све остале лиценце, овом лиценцом се ограничава највећи обим права коришћења дела.

4. **Ауторство – некомерцијално – делити под истим условима**. Дозвољавате умножавање, дистрибуцију и јавно саопштавање дела, и прераде, ако се наведе име аутора на начин одређен од стране аутора или даваоца лиценце и ако се прерада дистрибуира под истом или сличном лиценцом. Ова лиценца не дозвољава комерцијалну употребу дела и прерада.

5. **Ауторство – без прерада**. Дозвољавате умножавање, дистрибуцију и јавно саопштавање дела, без промена, преобликовања или употребе дела у свом делу, ако се наведе име аутора на начин одређен од стране аутора или даваоца лиценце. Ова лиценца дозвољава комерцијалну употребу дела.

6. **Ауторство – делити под истим условима**. Дозвољавате умножавање, дистрибуцију и јавно саопштавање дела, и прераде, ако се наведе име аутора на начин одређен од стране аутора или даваоца лиценце и ако се прерада дистрибуира под истом или сличном лиценцом. Ова лиценца дозвољава комерцијалну употребу дела и прерада. Слична је софтверским лиценцама, односно лиценцама отвореног кода.

Biography of the Author

Mazen Azzi, was born in 1976 in Lebanon. He dedicated his life to the field of sports and physical education. His passion for athletics began in his teenage years, guiding him toward a career in physical education. He pursued his academic journey at Antonine University in Lebanon, where he earned both his Bachelor's and Master's degrees in Physical Education.

Further refining his expertise, he obtained the Level 3 Basketball Coaching Certification from the Lebanese Basketball Federation, equipping him with advanced coaching methodologies. His commitment to athletic performance extended internationally, as he earned a certificate in physical conditioning for teams through Claude Bernard University in France.

Since 2000, he has been shaping young athletes as an EPS school teacher fostering both physical and personal growth in his students. His dedication to sports science is evident in his research contributions. He had published two scientific papers focusing on physical abilities and basketball training for youth.

Through his unwavering dedication to education, coaching, and scientific research, he continued to influence the next generation of athletes and professionals in the field of sports and physical education.

And Mazen is here in Belgrade university to continue his dream and earn his PHD.