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The Relationship Between Core Muscle Endurance, Dynamic Balance, and Some Physiological Factors in Young Football Players with Genu Varum

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Abstract

Background: Genu varum, a common knee alignment issue, may negatively affect physical performance in athletes, particularly in sports requiring balance, agility, and strength, such as football.

Objectives: This study aimed to examine the impact of genu varum on dynamic balance, core muscle endurance, and various athletic performance metrics in male football players.

Methods: This descriptive and correlational study included 42 young football players, 21 with genu varum and 21 without. All participants trained at least three times per week and were screened for genu varum using a caliper. After applying inclusion and exclusion criteria, the participants completed tests to assess dynamic balance, core muscle endurance, lower body strength, agility, and speed. Key performance evaluations included the Sargent Jump test, a 9x4 meter agility test, and a 36-meter sprint. Independent *t*-tests were conducted to compare the two groups. Statistical analyses were performed using SPSS version 22, with a significance level set at 0.05.

Results: Significant differences were found between the two groups. Players with genu varum showed reduced dynamic balance in all directions (anterior: P = 0.001, posterior-medial: P = 0.002, posterior-lateral: P = 0.004), lower body strength (P = 0.001), agility (P = 0.02), abdominal muscle endurance (P = 0.004), and sprint speed (P = 0.003) compared to players without genu varum.

Conclusions: The findings indicate that genu varum adversely affects essential athletic performance components, including balance, strength, agility, and speed, in young football players. These deficits may increase the risk of injury and impede long-term athletic development.

Keywords: Genu Varum, Young Athletes, Dynamic Balance, Agility, Lower Body Strength, Football, Performance

1. Background

Football is one of the most popular sports among youth worldwide, combining technical skills, physical fitness, and strategic thinking (1). Success in the sport heavily relies on physical attributes such as core muscle endurance, dynamic balance, and various physiological capabilities, including lower body power, agility, and speed (2, 3). These factors are critical for enhancing performance and preventing injuries (2), particularly as young players develop their athletic abilities. However, certain physical conditions, such as genu varum (bow-leggedness), may affect young athletes' ability to maintain these capabilities, potentially influencing their overall performance on the field (4, 5). In athletes with genu varum, the alignment of the lower limbs is altered (6), impacting how core muscles are engaged during movement. Genu varum is characterized by a lateral curvature of the legs, causing the knees to remain apart when the ankles are together (7). This misalignment can lead to compensatory movements in the hips and lower back, increasing the demand on the core muscles to maintain stability. Understanding how genu varum affects core muscle function is essential for

designing training programs to address these biomechanical challenges in young football players, helping them optimize their performance.

Core muscle endurance is fundamental for maintaining stability and controlling movements during high-intensity sports like football, where quick direction changes, rapid acceleration, and powerful kicks are frequent (8). Core muscles, including the abdominals, back, and pelvic floor, provide critical support for the spine, enabling efficient movement and power transfer between the upper and lower body (9, 10). Core muscular endurance is particularly beneficial for young athletes as it helps maintain proper posture and reduces the risk of lower back injuries (11, 12). For football players, core strength significantly contributes to balance and coordination during dynamic movements, which are vital for executing quick maneuvers and maintaining control of the ball (13). Dynamic balance, or the ability to maintain equilibrium while moving, is another essential component of athletic performance in football (14, 15). It requires coordination between muscles and joints to stabilize the body during activities like running, jumping, and changing direction (16). This skill is especially critical in football for maintaining control during high-speed maneuvers such as dribbling and tackling. Effective dynamic balance is closely linked to core stability, as a strong core helps stabilize the pelvis and spine during movement, providing a foundation for improved balance (17, 18).

Due to their altered lower limb mechanics, players with genu varum may find maintaining dynamic balance more challenging (19). This condition may lead to imbalances that increase the risk of falls or injuries during sports activities (20). Investigating the connection between dynamic balance and core endurance in these players can help coaches better understand the specific needs of young athletes with this condition and design targeted interventions to improve their stability and performance.

In addition to core endurance and dynamic balance, other physiological factors like muscle power, agility, and speed are vital for football players. Lower body power is crucial for explosive actions like jumping and sprinting, which are common in football (21, 22). Agility, the ability to quickly change direction while maintaining speed, is essential for outmaneuvering opponents and adapting to fast-paced situations (23).

Genu varum can potentially impact these physiological aspects by altering the distribution of forces during activities like running and jumping, which may reduce the efficiency of movements and lower the overall power output of the lower limbs (24). Additionally, compensatory movements to maintain balance might influence a player's agility and speed, making it essential to understand how this condition interacts with physical performance attributes in football (25).

Although core endurance, dynamic balance, and physiological factors are crucial in youth football, research on their interaction in players with genu varum is limited. Understanding these relationships can help coaches design targeted training programs to enhance performance and reduce injury risks. Improving core stability and balance through specific exercises may address some challenges of genu varum, helping young athletes perform better.

2. Objectives

This study aims to explore the relationship between core endurance, dynamic balance, and factors like power, agility, and speed in young footballers with genu varum. The findings could guide the development of tailored training programs to boost performance and minimize injuries.

3. Methods

This descriptive and correlational study was registered under the code SSRI.REC-2407-2789 with the Research Ethics Committee of the Institute of Physical Education and Sports Sciences. The study's target population comprised 298 male football players, aged 11 to 14, from Quchan city during the 2021 - 2022 academic year. Participants were screened for genu varum using a caliper. After applying the inclusion and exclusion criteria, 53 individuals were diagnosed with genu varum, of whom 21 were randomly assigned to the Genu Varum group. Similarly, 21 healthy individuals (without genu varum) were randomly selected to form the control group. Figure 1 provides a detailed overview of the participant enrollment and allocation process (Figure 1). All participants regularly attended at least three football training sessions per week but had no experience in championships or team memberships beyond the county level.

3.1. Inclusion and Exclusion Criteria

Participants were included if they had no history of lower limb injuries or surgeries within the past year, no musculoskeletal disorders affecting the study variables (except genu varum in the genu varum group), and no significant leg length discrepancy. Exclusion criteria included a history of lower limb or spine injuries or

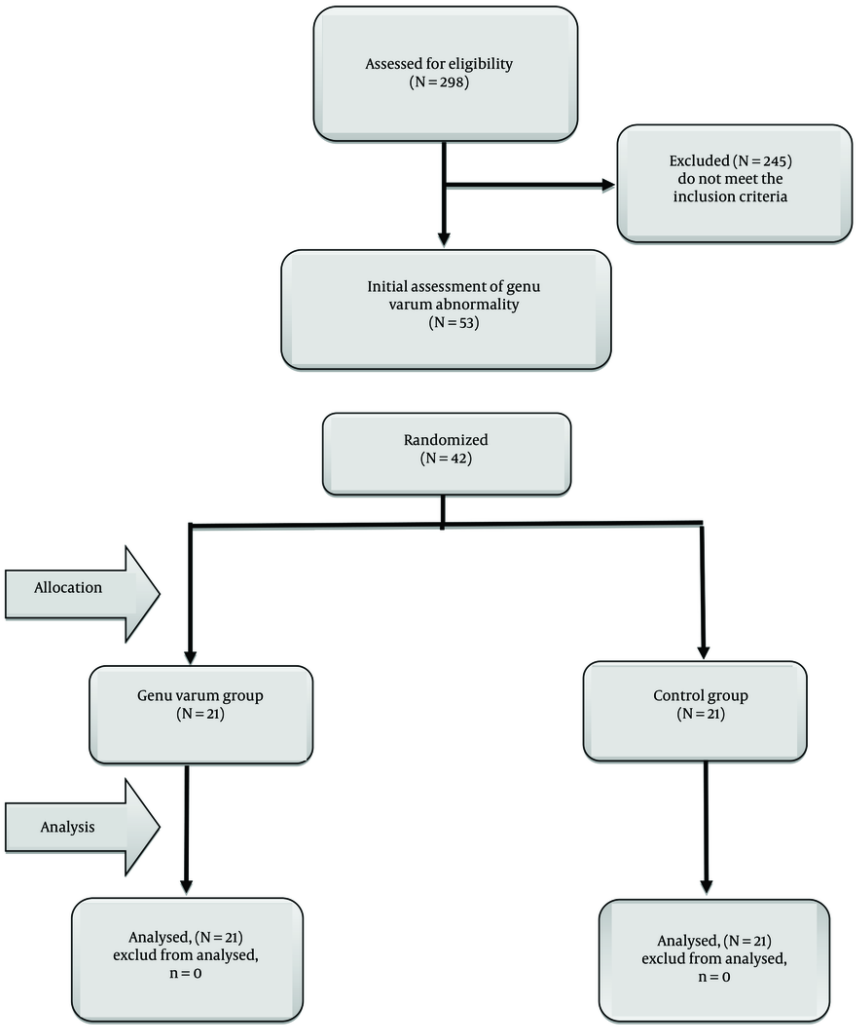

Figure 1. Consort flow chart for enrollment

surgeries, inner ear infections, uncorrected vision problems, head injuries, genu valgum, knee hyperextension, pelvic asymmetry, leg length discrepancies exceeding one centimeter, participation in professional sports, or a history of athletic championships.

3.2. Equipment

The study utilized the following equipment: A scale, stadiometer, stopwatch, cones, measuring tape, and a caliper (with an accuracy of 1 millimeter) to assess genu varum.

3.3. Measurement Procedures

Before taking any measurements, written informed consent was obtained from the players' parents. The consent form provided a detailed explanation of the study, including potential risks and benefits of participation. After securing consent, participants completed a questionnaire to provide demographic and medical history information. A caliper with 1 mm accuracy was then used to assess the condition of the knees.

Table 1. Demographic Characteristics of 11 -14-Year-Old Football Players

Variables	Healthy Group	Varus Knee Group
Age (y)	13.5 ± 1.50	13.12 ± 1.18
Height (m)	1.65 ± 0.55	1.64 ± 1
Weight (kg)	51.30 ± 3.48	53.50 ± 4.40
The distance between two condyles (cm)	0.60 ± 0.23	5.33 ± 0.70

3.4. Diagnosis and Measurement of Genu Varum

To diagnose genu varum, the individual stands with both medial malleoli (ankle bones) touching without applying any force. The distance between the medial epicondyles of the femur (thigh bone) is measured in this position. If the measured distance exceeds 3 centimeters, the condition is identified as genu varum (bow-legged). For accurate measurement, the subject stands barefoot with their knees and thighs fully exposed, ensuring the thigh muscles are relaxed. With knees fully extended and ankles touching, the patellae (kneecaps) must face forward. Using a caliper, the distance between the medial femoral condyles (just above the medial epicondyles) is measured. A distance of more than 3 centimeters confirms the presence of genu varum (26).

3.5. Assessment of Dynamic Balance

This study utilized the Y Balance test to assess participants' dynamic balance. The test required the subject to stand on one leg while reaching as far as possible with the other leg in three directions: Forward, backward, and laterally. The purpose of this test was to evaluate the individual's ability to maintain balance under conditions of maximum induced imbalance and their capacity to return to the initial balanced position. Each participant performed the reaching action with the non-supporting leg three times in each direction, totaling nine repetitions. A 15-second rest interval was provided between each repetition (27).

3.6. Assessment of Core Muscle Endurance

The McGill Side Plank Test was employed to assess core muscle endurance. In this test, participants lay on their sides on the ground, supporting themselves on one forearm and the side of the same-side foot. They were then instructed to raise their hips and maintain a straight line from head to heel for 10 seconds. The duration for which each participant could hold this position was recorded as their score for the test (28).

3.7. Physiological and Performance Assessments

In this study, standardized performance tests were employed to evaluate various components of physical fitness, including neuromuscular control, strength, power, and agility, aligning with the research objectives. The Sargent Jump Test was used to measure vertical jump height. Participants stood next to a vertical surface and marked the highest point they could reach with an outstretched arm after a vertical jump. The difference between the initial standing reach and the highest point marked represented the vertical jump height.

The 9 × 4 Meter Agility Test assessed agility and explosive power by requiring participants to sprint back and forth between cones placed 9 meters apart, covering a total distance of 36 meters. The time taken to complete this distance was recorded.

The 36-Meter Sprint Test measured sprinting speed. Participants sprinted along a straight 36-meter track, and the time taken to complete the sprint was recorded (29).

3.8. Statistical Analysis

The normality of the data distribution was evaluated using the Kolmogorov-Smirnov test, and group comparisons were conducted using independent *t*-tests. All statistical analyses were carried out using SPSS version 22, with the significance level set at 0.05.

4. Results

Table 1 presents the demographic characteristics of the participants.

The Kolmogorov-Smirnov test confirmed that the data for all study variables were normally distributed.

The results of independent *t*-tests revealed significant differences in various physical attributes between 11- to 14-year-old football players with and without genu varum. Players with genu varum demonstrated lower dynamic balance in all directions (anterior: P = 0.001, posterior-medial: P = 0.002, posterior-lateral: P = 0.004), reduced lower body strength (P = 0.001), decreased agility (P = 0.02), diminished abdominal muscle

Table 2. Independent *t*-test Results for Dynamic Balance, Lower Body Strength, Agility, Abdominal Muscle Endurance, and Speed in 11 - 14-Year-Old Football Players with and without Genu Varum

Variables	Healthy Group	Varus Knee Group	*t*-test	dF	P-Value
Dynamic balance					
Anterior (cm)	74.85 ± 11.5	64.55 ± 10.5	3.25	38	0.001
posterior internal (cm)	75.21 ± 14.5	63.33 ± 10.5	3.50	38	0.002
posterior external (cm)	75.25 ± 12.91	64.46 ± 7.81	4.20	38	0.004
LBMP- Sargent's Jump (cm)	40.50 ± 4.5	35.5 ± 3.5	5.50	38	0.001
Agility-test 4 × 9 (s)	8.46 ± 2.1	9.25 ± 2.5	2.5	38	0.02
AME-McGill planck test (s)	155.5 ± 20.5	86.30 ± 22.1	10.5	38	0.004
Speed 36 meter (s)	4.60 ± 1.5	5.50 ± 1.65	3.45	38	0.003

Abbreviations: LBMP-Sargent's Jump, lower body muscle power sargent's jump; AME-McGill planck test, abdominal muscle endurance-McGill planck test.

endurance (P = 0.004), and slower speed (P = 0.003) compared to players without genu varum (Table 2).

5. Discussion

This study aimed to investigate the relationship between genu varum, core muscle endurance, dynamic balance, and specific physiological factors, including lower body muscle power, abdominal muscle endurance, agility, and speed, in 11- to 14-year-old football players.

The findings revealed significant differences in dynamic balance, lower body strength, agility, abdominal muscle endurance, and speed between young football players with genu varum and those without. Players with genu varum demonstrated reduced dynamic balance across multiple directions, decreased lower body strength, diminished agility, lower abdominal muscle endurance, and slower speed compared to their counterparts without this knee alignment condition. These results align with prior research emphasizing the biomechanical challenges and physical limitations associated with genu varum in athletic performance.

The observed impairments in dynamic balance among players with genu varum corroborate the findings of Samaei et al., who reported that genu varum adversely affects postural stability and dynamic balance. According to Samaei et al., altered knee alignment in individuals with genu varum disrupts force distribution through the lower limbs and shifts the center of gravity, complicating balance maintenance (20). However, Chae et al., in a study on non-athlete populations, found no significant differences in dynamic balance between individuals with genu varum and control groups for certain balance indices. This discrepancy could be attributed to differences in population type and assessment methods (19).

Regarding lower body strength, the findings align with those of Chae et al., which identified that malalignment conditions like genu varum hinder muscle recruitment around the knee joint, resulting in reduced overall strength (19). In contrast, Jafarzadeh et al. highlighted that corrective exercises could address these strength deficits, particularly through short-term interventions, suggesting that targeted training programs might mitigate these impairments. This stands in contrast to the chronic impacts of genu varum observed in the current study (30).

Agility impairments in players with genu varum align with the findings of Jafarzadeh et al., who reported that genu varum adversely affects biomechanics, reducing movement efficiency and ultimately impairing agility in athletes (30). Additionally, this study's findings regarding reduced abdominal muscle endurance are consistent with Santos et al., who emphasized the critical role of core muscle endurance in maintaining balance and athletic performance. The implication is that players with genu varum may experience compromised core stability due to altered lower limb alignment. However, direct research focusing on core endurance specific to genu varum remains limited and warrants further investigation (31).

The observed decrease in sprinting speed in this study is supported by research from Jafarnezhadgero et al., which indicated that individuals with genu varum experience higher ground reaction forces, reducing sprinting efficiency (32). Conversely, studies such as Jafarzadeh et al., which examined the effects of corrective exercises or younger populations, suggest that speed deficits can be mitigated with targeted interventions. These contrasting findings indicate that factors such as age, type of training, and intervention approaches may significantly influence outcomes (30).

This study is limited by its small sample size, which may affect the robustness of the conclusions, and its focus on young male football players aged 11 to 14 from Quchan city, restricting the generalizability to other populations. The use of specific tools like calipers may have introduced variability in measurements, and the participants' lack of advanced athletic experience limits applicability to more diverse or professional athlete groups. The practical application of this research lies in developing targeted training programs to enhance balance and athletic performance in football players with structural knee issues, such as genu varum. Future studies should incorporate diverse age groups and sports disciplines and investigate the effects of specific training on core muscle endurance and dynamic balance in athletes with genu varum.

5.1. Conclusions

The study concludes that genu varum in young football players significantly affects athletic performance, as these athletes demonstrate reduced dynamic balance, lower body strength, agility, abdominal muscle endurance, and speed compared to peers without this knee alignment issue. These findings reinforce prior research linking genu varum to diminished performance in dynamic activities requiring balance and strength, as well as an increased risk of injury. Recognizing these challenges, the study highlights the importance of coaches and trainers implementing targeted training programs tailored to athletes with genu varum. Further research is recommended to evaluate the effectiveness of such programs and to explore long-term outcomes aimed at enhancing performance and preventing injuries in youth sports.

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Footnotes

Authors' Contribution: M .S. A., K. K., and A. H. S. contributed to the study conception and design, and A. H. S. performed clinical examination and data collection. M. S. A. and K. K. participated in the methodological development and design of the statistical analysis. M. S. A. wrote the first draft of the manuscript and contributed to the comments and suggestions that significantly improved the manuscript. Finally, all the authors revised it critically for important intellectual content, agreed with the content, contributed to the current study's refinement, and approved the final manuscript.

Conflict of Interests Statement: The authors declared no conflict of interests.

Data Availability: The dataset presented in the study is available on request from the corresponding author during submission or after publication.

Ethical Approval: The Human Ethics Research Committee approved this study of the Sport Sciences Research Institute of Iran according to compliance with the Ethical Standards in Research of the Ministry of Science, Research and Technology, with the SSRI.REC-2407-2789 code.

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Informed Consent: For participating minors under the age of 16, informed consent was obtained from the parents, legal guardians, or next of kin. The parents or legal guardians were fully informed about the nature of the study, and their consent was obtained before any minors were involved in the research.

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