IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

INTRA-RATER AND INTER-RATER RELIABILITY OF QUADRANT JUMP TEST FOR ASSESSING AGILITY IN FOOTBALL PLAYERS: A CROSS-SECTIONAL STUDY

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Abstract: Study Design: Cross-Sectional Study

Background: Agility is an important component in football for better performance and achieving the highest scoring in matches. There are numerous tests used to measure agility in football players. Most of these tests focus on measuring changes in physical attributes rather than a combination of physical and cognitive attributes. The quadrant jump test is advantageous due to its simplicity, speed, minimal equipment requirement, and ability to measure both physical and cognitive variables simultaneously.

Aims: To assess the intrarater and interrater reliability of the quadrant jump test in evaluating agility among football players.

Method: 143 elite football players (M=138, F=5) underwent the quadrant jump test. The evaluation of the test was taken by two testers for inter-rater reliability and by one of the testers after a gap of seven days for intra-rater reliability.

Results: Participants were divided into adolescents (n=54) and young adults (n=89) for separate analysis. The intraclass correlation coefficient (ICC) demonstrated excellent reliability for both intrarater and interrater assessments in both groups. In adolescents, ICC for interrater reliability was 0.72, and intrarater reliability was 0.96. In adults, ICC for interrater reliability was 0.93, and intrarater reliability was 0.89. Standard error of measurement (SEM) and smallest real difference (SRD) values were also analyzed.

Conclusion: The quadrant jump test exhibits robust reliability in assessing agility in both adolescent and adult football players, underscoring its utility as a measurement tool.

Keywords: Agility test, Quadrant Jump Test, Football Player

INTRODUCTION

One of the most popular sports in the world is football, which relies heavily on psychological, technical, tactical, and physical aspects. It is estimated that there are over 240 million elite football players worldwide, the sport highlights a diverse range of skills and widespread appeal. [1,2] Playing football demands quick, non-continuous movement and involves frequent physical contact. [3] Football players frequently execute explosive motions such as kicking, tackling, jumping, sprinting, and rapid direction changes. [4] Recent trends in football and other international sports underscore the significance of physical preparation for optimal performance and readiness [5]

Physical readiness is correlated with position on the pitch and body composition, and the degree of technical expertise [6,7]. The goalkeeper's role is to prevent the opposing team's goals. [8] Defenders mark opposing players, intercept passes, make tackles,

and clear the ball out of dangerous areas. [9] Midfielders control the game's tempo, distribute the ball, and contribute to both offensive and defensive phases. [10] Frontcourt players utilize their skill and positioning to get behind the opposition's defenses, receive the passes, and take shots on goal. [11] Training programs are meticulously designed to optimize players' physical fitness, encompassing speed, strength, agility, endurance, and technical skill. [12,13]

Agility is a pivotal component in football, facilitating players' rapid adaptation to the dynamic and unpredictable nature of the game. [14] This complex skill, influenced by factors like strength, endurance, speed, balance, and coordination, is fundamental for success on the field. [15,16] Recognized as essential, agility enables players to execute movements efficiently within tight timeframes and make quick decisions amidst shifting circumstances. [14,17] Integrating agility training into overall programs becomes imperative to ensure players can effectively meet the game's demands and perform optimally. Notably, football players change direction frequently during a match, [18] highlighting the significance of agility in sustaining peak performance and gaining a competitive edge in the sport. [19,20]

The traditional definition of agility has evolved to encompass more than just rapid directional changes, [21-23] now including elements like balance, coordination, and adaptability to environmental shifts. [24] Specialists consider agility a complex motor skill, emphasizing its multifaceted nature. [25] This contemporary understanding recognizes that agility requires not only quick changes in direction but also the ability to anticipate, react, and make decisions in dynamic situations, particularly in team sports like football. [26]

Moreover, recent research highlights the dynamic and power-intensive nature of agility, linking it closely with movements such as maximal jumping and sprints. [27] These movements demand rapid force development, high power output, and efficient utilization of the stretch-shortening cycle, all crucial components of agility performance. [28] Additionally, studies have found correlations between lower limb power and agility, further emphasizing the importance of strength and power in executing agile movements effectively. [29]

In summary, agility in sports involves a combination of physical attributes, including speed, power, and coordination, along with cognitive skills like perception and decision-making. [24,26,27,30] Understanding and assessing agility requires considering its multifunctional nature and dynamic interplay between physical and cognitive elements. [26]

In team sports like football, agility is a critical attribute, yet many testing protocols primarily focus on the change of direction speed (CODS) and neglect reactive agility (RAG), which involves responding to unpredictable stimuli. It's vital to distinguish between these two forms of agility to understand their cognitive and physical determinants. [31] While physical attributes like sprinting speed are more linked to CODS, perceptual and cognitive capacities significantly influence RAG. [31,32] Unfortunately, there's a dearth of research examining factors associated with both CODS and RAG in football specifically. Addressing this gap could inform more targeted training programs, enhancing players' agility for better on-field performance. [33]

The quadrant jump test assesses both Change of Direction Speed (CODS) and Reactive Agility (RAG) by simulating real-game scenarios involving rapid direction changes and responses to unpredictable cues. It measures participants' ability to make quick decisions and execute precise movements, reflecting both cognitive agility and physical speed. Faster completion times indicate superior CODS, crucial for evading opponents and maneuvering effectively during gameplay. Overall, the test provides a comprehensive evaluation of agility, making it valuable for assessing athletes in sports like football where quick reactions and directional changes are vital.

There is no literature that finds the reliability of the quadrant jump test to evaluate agility in football players. Thus, the purpose of this study is to determine the intra-rater and inter-rater reliability of quadrant jump test for evaluating agility in football players.

RESEARCH METHODOLOGY

This cross-sectional was done on football players and data were collected from various football academies in the South Gujarat region. For, the collection of data convenient sampling technique was used.

Sample size

ICC = 0.7			ICC = 0.8		
m repeated measurements	95% CI ± 0.1 *n*	95% CI ± 0.2 *n*	*m* repeated measurements	95% CI ± 0.1 *n*	95% CI ± 0.2 *n*
2	100	25	2	50	13
3	67	17	3	35	9
4	56	14	4	30	8
5	50	13	5	28	7
6	47	12	6	26	7

Assuming the value of R (reliability value of Intra-class correlation coefficient) was to be 0.80 or more with a 95% confidence interval, a total of 138 individuals were required for the present study. But considering the dropout rate, which was assumed to be 5-10%, a total of 143 subjects were included in the study.

Inclusion criteria

- Age (10-30 years)
- Minimum hours playing per day (2-4 hours)
- Minimum number of years playing (2 years)
- Both males and females
- Individual willingness to participate

Exclusion criteria

- History of surgery in spine, hip, knee, and ankle joint
- History of acute trauma in hip, knee, and ankle joint
- Ankle instability
- Metabolic disease
- Any lower limb arthritis
- Neurological problem
- Cardiovascular or respiratory problem
- Any disability presents

Procedure

In this cross-sectional study, a total of 143 individuals were included in the study, based on the inclusion and exclusion criteria. All the individuals were selected from the various football academies from the south Gujarat region. Consent was obtained from all the individuals and the individuals were screened through quadrant jump tests. The entire screening procedure was done by one physiotherapy student apart from the two testers.

Measurements were taken by the two physiotherapy students to test the inter-rater reliability of the quadrant jump test twice at intervals of 10-15 minutes. Measurements were taken by the same physiotherapy student on two different days with seven days intervals for intra-rater reliability.

The test content and procedures were briefly explained by each tester, but no specific training was conducted. The test sessions began with standardized verbal instructions and a tester demonstrated the quadrant jump test. The individuals were not given any trial or practice. The test was conducted with the procedure mentioned in the outcome measure.

Both the testers recorded the score on the scoring sheet and to avoid the exchanging of information, both testers were blinded to the score taken by each other. This procedure was followed for inter-rater reliability.

Individuals were not told the scores that they achieved during the first test to avoid bias on the results of the performance level of the individuals, and the procedure was repeated after seven days and data thus obtained was used to calculate for intra-rater reliability. The same testing procedure and equipment were used for all individuals.

Figure 1: Testers scoring quadrant jump test for intra-rater reliability

Figure 2: Testers scoring quadrant jump test for inter-rater reliability

STATISTICAL ANALYSIS

Data analysis was done using the SPSS software (version 25.0).

Results were considered significant level at $p<0.05$ and a confidence interval of 95%.

Data analysis is done by:

- Intra-class correlation coefficient for inter-rater reliability which is regarded as a key indicator of reliability. (52)
- Bland-Altman limits of agreement analysis for assessing the agreement between rater scores. (53)
- Standard error of measurement (SEM) to calculate the variability in measurements of the same individual. The true measurement can be calculated as 1.96*SEM. (54)
- Smallest real difference (SRD) is the smallest change that can be interpreted as a real difference. It is calculated as SRD = $1.96*\sqrt{2}*SEM$. (55)

Table 1.1: Gender distribution of individuals

	Male	Female	Total
Frequency	138	5	143
Percentage	95.8%	3.5%	100%

Table 1.1 shows the gender distribution of all individuals in that 5 are female and 138 are male from a total of 143 subjects.

Table 1.2: Descriptive statistics of demographic data

	N	Minimum	Maximum	Mean	Standard Deviation
Age	143	10	29	18.91	5.33
Weight (kg)	143	26	85	55.55	13.90
Height (cm)	143	110	192	155.13	16.44
BMI (kg/m^2)	143	18.1	31.6	22.72	3.11
No. of years playing	143	1	15	5.14	3.56
No. hours playing /day	143	1	6	2.21	0.97

Table 1.2 shows descriptive statistics of demographic data as mean and standard deviation with minimum and maximum values.

Table 1.3: Descriptive statistics of quadrant jump test in the adolescent group (10-17)

	N	Minimum	Maximum	Mean	Standard Deviation
Rater 1(1^{st} Day)	54	15	31	23.77	4.31

Rater 2	54	16	31	25.20	3.95
Rater 1(7th Day)	54	16	32	24.40	3.95

Table 1.3 shows the descriptive statistics of quadrant jump tests in the adolescent group as mean and standard deviation with minimum and maximum values.

Table 1.4: Descriptive of quadrant jump test in the young adult group (18-30)

	N	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**
Rater 1(1st Day)	89	17	33	28.15	3.53
Rater 2	89	18	34	28.89	3.49
Rater 1(7th Day)	89	20	31	27.24	2.67

Table 1.4 shows the descriptive statistics of quadrant jump tests in the adult group as mean and standard deviation with minimum and maximum values.

Table 1.5 Correlation between BMI and quadrant jump test

	r-value	**P value**
Adolescent group	-1.66	0.22
Adult group	-0.63	0.561

Table 1.5 shows no correlation between the BMI and quadrant jump test in both groups.

Table 1.6 Intra-rater and inter-rater ICC, CI, and Cronbach alpha of quadrant jump test in adolescent group (10-17)

	Rater 1 with Rater 2	**Rater 1 (1st day-8th day)**
ICC	0.72	0.96
CI (Upper)	0.84	0.94
CI (Lower)	0.52	0.98
Cronbach alpha	0.72	0.96

Table 1.6 shows intra-rater and inter-rater ICC (Intra-class correlation coefficient), Cronbach alpha, and CI (Confidence Interval) from upper bound to lower bound at p-value <0.05 of the quadrant jump test in the adolescent group (10-17). The ICC value showed fair reliability in the interrater group, whereas the ICC value showed excellent reliability in the intrarater group in the adolescent group

Table 1.7 Intra-rater and inter-rater ICC, CI, and Cronbach alpha of quadrant jump test in young adult group (18-30)

	Rater 1 with Rater 2	Rater 1 (1st day-8th day)
ICC	0.93	0.89
CI (Upper)	0.95	0.93
CI (Lower)	0.89	0.84
Cronbach alpha	0.93	0.89

Table 1.7 shows the quadrant jump test in the adult group (18-30) group intra-rater and inter-rater ICC (Intra-class correlation coefficient), Cronbach alpha, and CI (Confidence Interval) from upper bound to lower bound at p-value <0.05. The ICC value showed excellent reliability in both interrater and intrarater groups in the young adults group.

Table 1.8 SEM of inter-rater and intra-rater reliability of quadrant jump test

		Rater 1 with Rater 2	Rater 1 (1st day-8th day)
SEM	**Adults**	2.04	0.31
	Adolescents	0.48	0.65

The SEM (Standard error of measurement) is a measure of absolute reliability.

The SEM value was calculated for variability in measurements between raters. The smaller the SEM more reliable the measurement. (54)

SEM is calculated by the formula:

SEM = SD*√1-ICC

In the above formula, SD (Standard deviation) and ICC are taken from the reliability testing procedure from Intra and inter-raters.

Table 1.8 shows the SEM variability between raters of the quadrant jump test in the adult and adolescent groups. Variability in measurements between rater 1 and rater 2, rater 1 (1st day-8th day) in the adult group are 2.04 and 0.31 respectively, so rater 1 (1st-8th day) has small value compared to rater 1 and 2 indicates measurements are very reliable and consistent in intrarater then interrater. Variability in measurements between rater 1 and rater 2, rater 1 (1st day-8th day) in the adolescent group are 0.48 and 0.65 respectively, which are very small and indicate the measurements are very reliable.

Table 1.9: SRD of inter-rater and intra-rater reliability of quadrant jump test in young adult and adolescent groups

		Rater 1 with Rater 2	Rater 1 (1st day-8th day)
SRD	**Adults**	3.95	1.54
	Adolescents	1.92	2.23

SRD (The smallest real difference) can be calculated by the formula:

SRD = 1.96*√2SEM (55)

Table 4.9 shows the SRD variability between raters of the quadrant jump test in the adult and adolescent groups. Variability in measurements between rater 1 and rater 2, rater 1 (1st day-8th day) in the adult group are 3.95 and 1.54 respectively. Variability in measurements between rater 1 and rater 2, rater 1 (1st day-8th day) in the adolescent group are 1.92 and 2.23 respectively.

Bland-Altman Graph

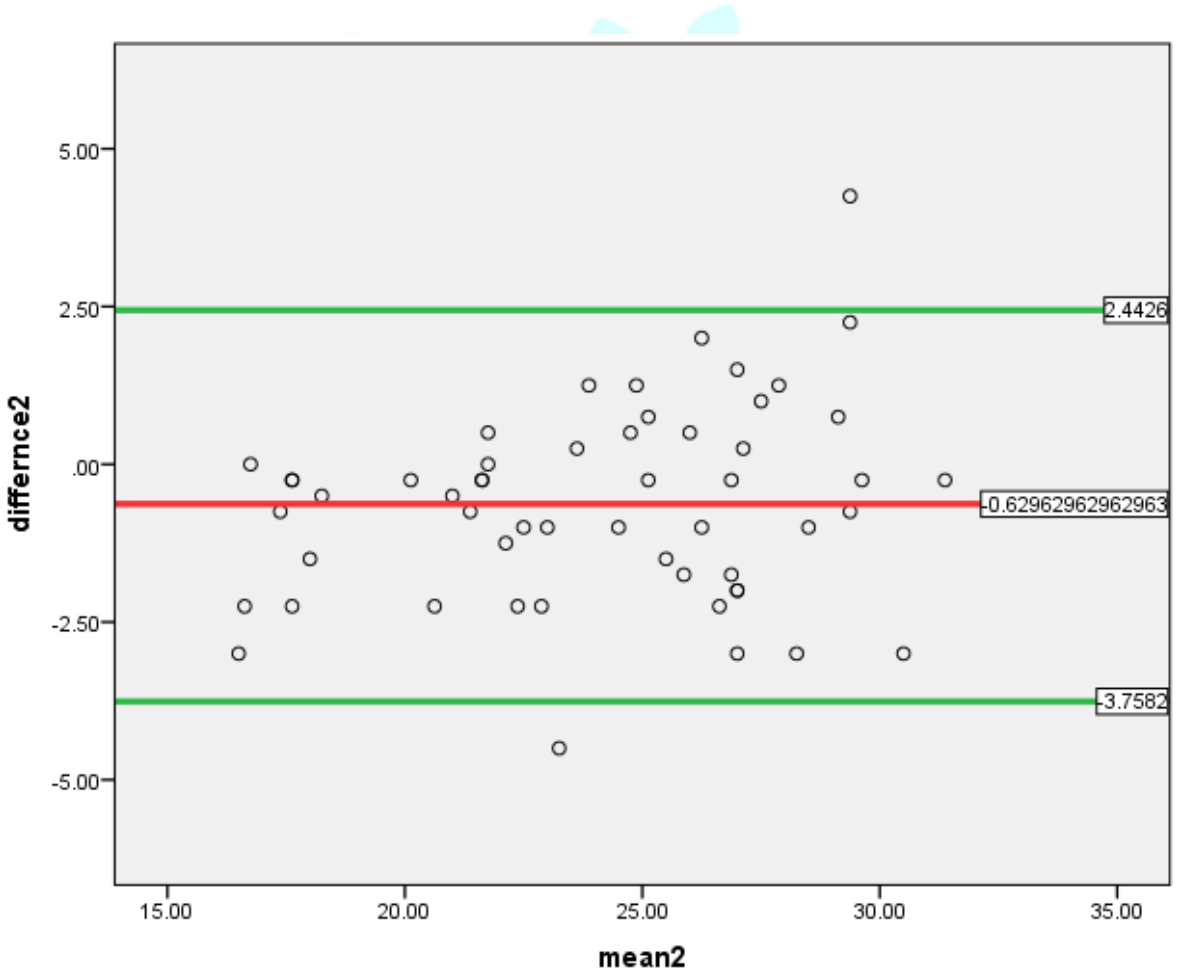
The Bland-Altman Graph can be used to analyse the limit of agreement between 2 raters of the quadrant jump test. The Bland-Altman plot is measured within subject variation and the limits of the agreement. [53] This will be created by plotting the mean difference in the quadrant jump test for the two occasions.

The Bland-Altman chart is a scatter plot with a difference of two measurements for each sample on the vertical axis and the average of the two measurements on the horizontal axis.

Three horizontal reference lines are superimposed on a scatter plot in that one line on average.

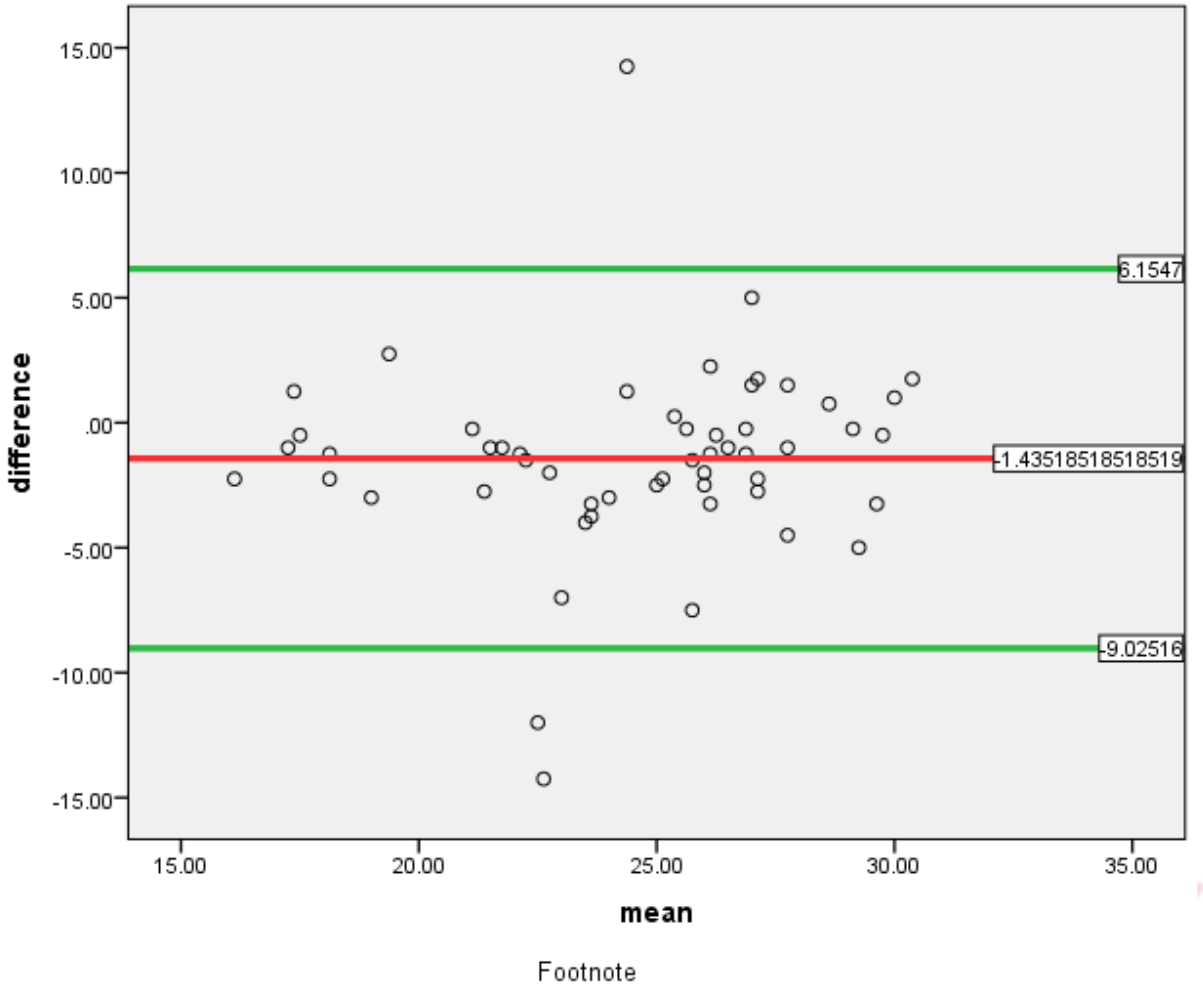
There is a difference between the measurements and lines to mark the upper and lower control of limits.

If the two measurements are comparable, the differences should be small, with the mean of differences close to 0. It shows reasonable agreement between the measurements if most of the values fall in M ± 2SD ($p<0.05$), it indicates excellent reliability.



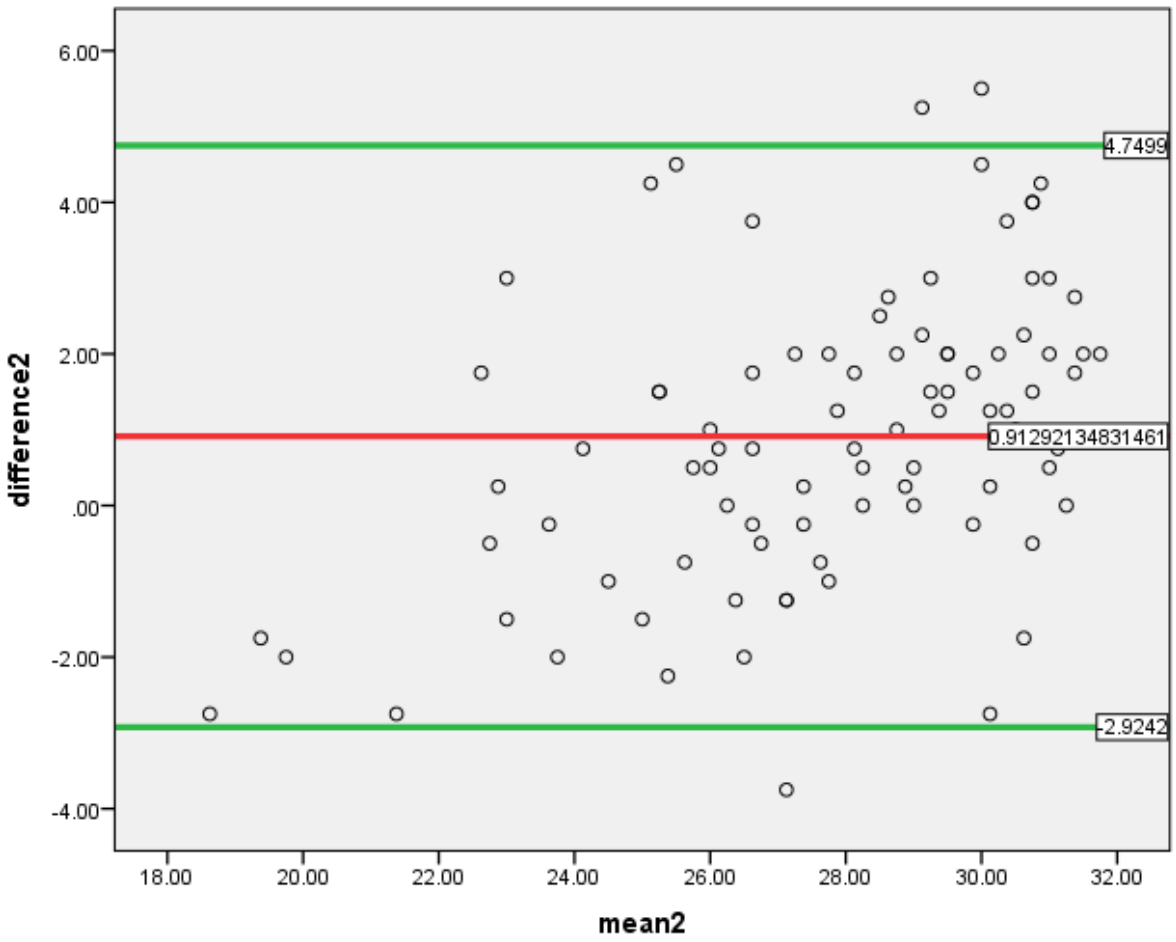
Graph 1: Bland Altman plot for intra-rater reliability in adolescent group

Graph 1 shows the Bland-Altman scatter plot for intra-rater reliability with the mean difference between the 2 measurements of the quadrant jump test in the adolescent group on the y-axis and the average of the two measurements on the x-axis. Since most of the values of M ± 2SD ($p=0.05$), indicated excellent reliability.



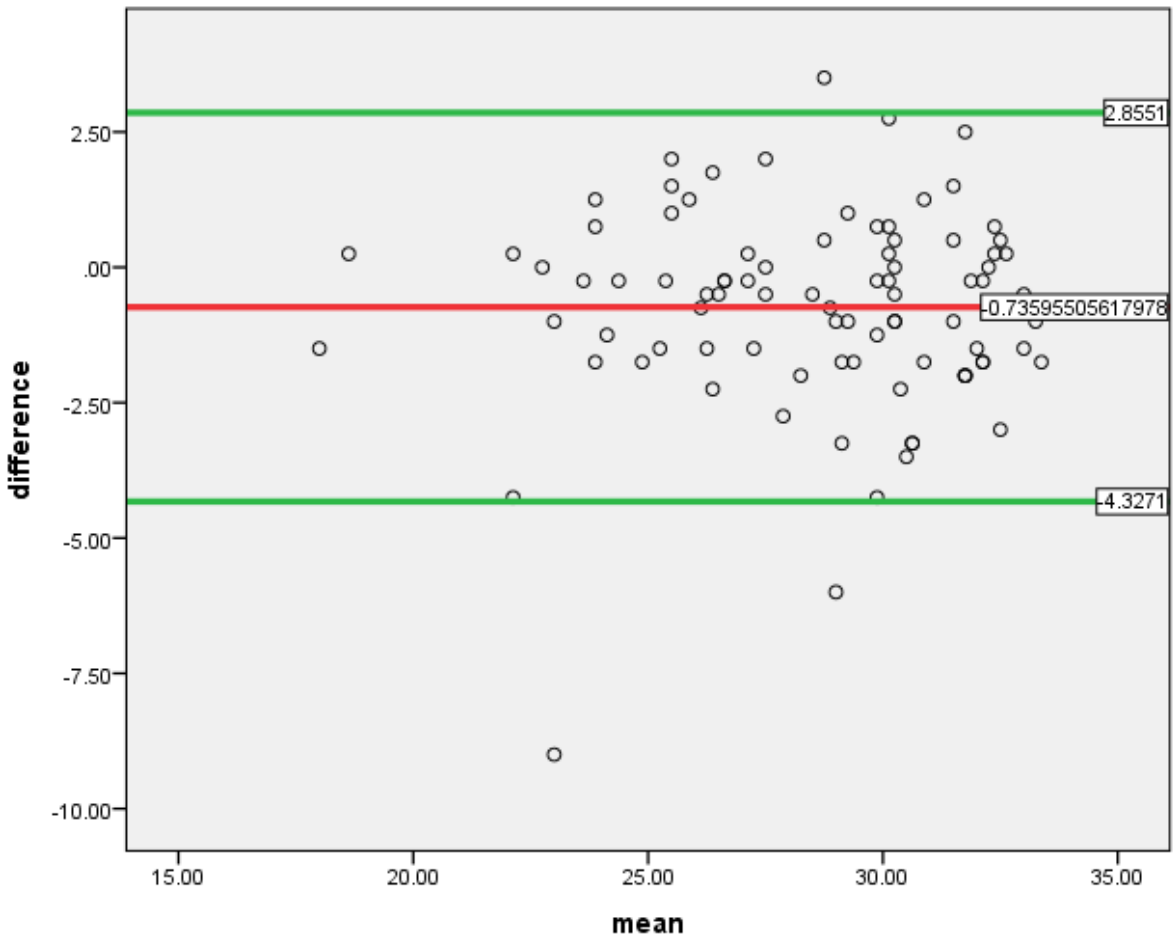
Graph 2: Bland Altman plot for inter-rater reliability in adolescent group

Graph 2 shows the Bland-Altman scatter plot for inter-rater reliability with the mean difference between the 2 measurements of the quadrant jump test in the adolescent group on the y-axis and the average of the two measurements on the x-axis. Since most of the values of M ± 2SD (p=0.05), indicated excellent reliability.



Graph 3: Bland Altman limits plot for intra-rater in the adult group

Graph 3 shows the Bland-Altman scatter plot for intra-rater reliability with the mean difference between the 2 measurements of the quadrant jump test in the adult group on the y-axis and the average of the two measurements on the x-axis. Since most of the values of M ± 2SD (p=0.05), indicated excellent reliability.



Graph 4: Bland Altman plot for inter-rater in the adult group

Graph 4 shows the Bland-Altman scatter plot for inter-rater reliability with the mean difference between the 2 measurements of the quadrant jump test in the adult group on the y-axis and the average of the two measurements on the x-axis. Since most of the values of M ± 2SD (p=0.05), indicated excellent reliability.

DISCUSSION

This cross-sectional study aims to assess the intrarater and interrater reliability of the Quadrant Jump Test for agility evaluation in football players. The test stands out for its integration of cognitive and physical elements, mimicking real-game scenarios. It emphasizes multidirectional movements specific to football and incorporates unpredictable stimuli, crucial for reactive agility assessment. Combining elements of Change of Direction Speed and Reactive Agility, it provides a comprehensive agility evaluation.

In the present study, there were 138 male and 5 female participants, indicating a predominance of males. Participants were categorized into two groups: adolescents (54 individuals) and young adults (89 individuals). This division allows for separate analysis of data within each group.

To find out the reliability of the quadrant jump test for evaluating agility in football players. By the analyzed ICC value. ICC (intra-class correlation coefficient) is measured on a scale of 0 to 1 in which 1 represents perfect reliability with no measurement error whereas 0 indicates poor reliability between raters. An ICC of 0.80 or higher indicates excellent reliability. A value of 0.60 to 0.80 indicates moderate reliability and a value of ICC of 0.40 to 0.60 indicates poor reliability.

In the present study for the adolescents group, the inter-rater reliability ICC (R1, R2) between rater 1 and rater 2 is 0.72, with a confidence interval of 0.52 to 0.84, indicating moderate reliability at a significance level of $p < 0.05$. Regarding intra-rater reliability, the ICC value for rater 1 between the 1st and 8th day is 0.96, with a confidence interval of 0.98 to 0.94, demonstrating excellent reliability at a significance level of $p < 0.05$.

In the present study for the adult group, the inter-rater reliability ICC (R1, R2) between rater 1 and rater 2 is 0.93, with a confidence interval of 0.95 to 0.89, indicating excellent reliability at a significance level of $p < 0.05$. Regarding intra-rater reliability, the ICC value for rater 1 between the 1st and 8th day is 0.89, with a confidence interval of 0.93 to 0.84, demonstrating excellent reliability at a significance level of $p < 0.05$.

In the present study concerning the adolescent group, the internal consistency of the quadrant jump test was assessed using Cronbach's alpha. For inter-rater reliability, the Cronbach's alpha value is 0.72, indicating moderate reliability. Conversely, for intra-rater reliability, the Cronbach's alpha value is 0.96, indicating excellent reliability.

In the present study concerning the adult group, the internal consistency of the quadrant jump test was assessed using Cronbach's alpha. For inter-rater reliability, the Cronbach's alpha value is 0.93, indicating excellent reliability. Conversely, for intra-rater reliability, the Cronbach's alpha value is 0.89, indicating excellent reliability.

In the present study within the adolescents group, the Bland-Altman analysis revealed good inter-rater agreement between rater 1 and rater 2, with limits of agreement ranging from 6.15 to -9.02. Similarly, the Bland-Altman analysis between two occasions by rater 1 on day 1 and day 7 showed good agreement, with limits of agreement ranging from 2.44 to -3.76.

In the present study within the adult group, the Bland-Altman analysis revealed good inter-rater agreement between rater 1 and rater 2, with limits of agreement ranging from 2.85 to -4.33. Similarly, the Bland-Altman analysis between two occasions by rater 1 on day 1 and day 7 showed good agreement, with limits of agreement ranging from 4.75 to -2.92.

For making a more reliable SEM value, the MDC value and item correlation should be checked so that it analyzes reliability in more detail and bias can be detected by all these values. Bland-Altman plots revealed no systematic bias in the present study in both groups. In terms of absolute reliability, no systematic bias was found for inter-rater nor intra-rater reliability and, thus, it seems that sportsmen can be confident in using these agility tests to evaluate dynamic balance, lower limb power, and agility in adolescent and young adult football players.

To enhance the reliability of the Standard Error of Measurement (SEM) value, it's crucial to assess the Minimum Detectable Change (MDC) value and item correlation, enabling a more detailed analysis of reliability and detection of bias. In the present study, Bland-Altman plots indicated no systematic bias in either group. Absolute reliability analysis revealed no systematic bias for both inter-rater and intra-rater reliability in either group. Therefore, it appears that athletes can confidently utilize these agility tests to evaluate dynamic balance, lower limb power, and agility in adolescent and young adult football players.

In the present study, for the adolescent group, the Standard Error of Measurement (SEM) value for inter-rater reliability is 0.48, while the SEM value for intra-rater reliability is 0.65. These values suggest minimal error between raters, indicating good agreement. The low error rate and high accuracy achieved in this study fulfill its aims effectively.

In the present study, for the adult group, the Standard Error of Measurement (SEM) value for inter-rater reliability is 2.04, while the SEM value for intra-rater reliability is 0.31. These values suggest a mild increase in error between raters, indicating good agreement. The low error rate and high accuracy achieved in this study fulfill its aims effectively.

The smallest real difference shows how far the score of the quadrant jump test in different raters as well as after giving treatment and how much improvement comes determined by SRD.

In the present study in the adolescent group MDC or SRD of the present study shows a real difference in inter-raters 1.92 and for intra-raters is 2.23. Respectively, the adult group shows a real difference in inter-raters 3.95 and for intra-raters is 1.54.

In the present study, the Minimum Detectable Change (MDC) or Smallest Real Difference (SRD) indicates the magnitude of change in scores of the quadrant jump test between different raters and before and after football training, reflecting improvement. In the adolescent group, the MDC or SRD for inter-raters is 1.92, and for intra-raters is 2.23. Conversely, in the adult group, the MDC or SRD for inter-raters is 3.95, and for intra-raters is 1.54. These values highlight the real differences observed in scores between raters and over time, aiding in interpreting the effectiveness of football training.

Based on the robust findings from various reliability measures such as the high ICC values, indicating strong agreement between raters and across different testing occasions, along with the satisfactory Cronbach's alpha values, demonstrating internal consistency, the quadrant jump test emerges as highly reliable for assessing agility in elite football players in adolescent and adult group.

The present study shows no correlation between BMI and the quadrant jump test. In contrast to our study, **Taghinejad, *et al*** [56] reported that a higher body mass index (BMI) correlates with weaker sports performance. The findings highlight an inverse significant correlation between BMI and agility records, shedding light on the relationship between body type, composition, and performance in basic movement patterns and soccer skills.

Collectively, these findings provide solid evidence that the quadrant jump test is a dependable tool for evaluating agility in football players, offering coaches, scouts, and sports scientists a valuable means to assess and monitor players' performance and development in this critical aspect of athleticism. Therefore, its reliability underscores its importance and utility in talent identification, player development, injury prevention, and performance optimization strategies, ultimately contributing significantly to the success of football players on the field.

CONCLUSION

The present study demonstrates the robust reliability of the quadrant jump test for evaluating agility in both adolescent and adult populations, affirming its effectiveness as a measurement tool. This assessment method, designed to gauge change of direction speed (CODS) and reactive agility (RAG), replicates real-game scenarios characterized by swift directional changes and responses to unforeseen stimuli. By requiring participants to swiftly adapt and execute precise movements, the test effectively captures the integration of cognitive agility with physical speed. The findings underscore the quadrant jump test's utility as a comprehensive evaluation tool, offering valuable insights into individuals' ability to make rapid decisions and execute agile movements, essential attributes in various sports and real-world contexts.

LIMITATION OF STUDY

This study was conducted exclusively with adolescent and young adult groups; therefore, the results cannot be generalized to all age groups.

FUTURE RECOMMENDATION

- To check the validity of the test.
- To perform the test on players within the same BMI group.

ACKNOWLEDGMENT

- The authors would like to thank all participants who assisted in the study.

FUNDING

- This research received no specific grants from any funding agency in the public commercial or non-profit sectors.

DECLARATION OF INTEREST

- The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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