

# **Correlation Between Functional Movement Quality, Pain, and Fundamental Physical Fitness Performance in Elite Female Softball Athletes: A Cross-Sectional Analysis**

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**Abstract:** This study conducted functional movement screen, body pain assessment, and fundamental physical fitness testing on 30 elite female softball athletes to explore the relationships among these indicators, thereby providing a basis for athlete condition diagnosis and targeted training. The testing content included shoulder mobility, ankle mobility, deep squat, active straight leg raise, as well as standing long jump, 30 m sprint, 3000 m run, bench press (1RM), relative strength, and inverted row. Six pain sites and a total pain index were recorded. Spearman correlation analysis showed that ankle mobility was positively correlated with deep squat scores ( $r=0.562$ ,  $p<0.001$ ). A total of 27 pain reports were recorded, and the total pain index was negatively correlated with shoulder mobility and deep squat scores ( $r=-0.421$ ,  $-0.387$ ,  $p<0.05$ ). Standing long jump was negatively correlated with 30 m sprint time ( $r=-0.563$ ,  $p<0.001$ ), and 3000 m run time was positively correlated with 30 m sprint time ( $r=0.593$ ,  $p<0.001$ ). Among FMS indicators and physical fitness performance, only the shoulder score was correlated with bench press performance ( $\rho=0.446$ ,  $p=0.029$ ). These results indicate that ankle joint function in female softball athletes is closely related to key lower-limb movement patterns, and pain is associated with declines in certain movement qualities. The overall correlation between FMS and physical fitness performance is relatively weak, suggesting that they should be jointly applied for training monitoring and risk screening.

**Keywords:** Softball; FMS; Pain Assessment; Physical Fitness; Correlation

## **1. Introduction**

Functional Movement Screen (FMS) [1] is a systematic movement pattern assessment tool

based on mobility and stability. Through seven fundamental movement patterns and three clearing tests, it evaluates functional deficits as well as compensatory and asymmetrical movement patterns to predict injury risk [2-3], and has been widely applied in competitive sports and public fitness settings [4-9]. In competitive softball, athletes require high levels of explosive power [10], multidirectional movement ability and repetitive throwing [11], as well as hitting performance [12]. These sport-specific techniques are all built upon sound fundamental movement patterns, while injuries are important factors affecting training quality and competitive performance [13-15]. At present, there is still a lack of systematic empirical research examining whether intrinsic relationships exist among FMS movement quality, pain status, and multiple fundamental physical fitness performances in elite female softball athletes. Clarifying the relationships among these variables can help coaches and strength and conditioning professionals quickly grasp athletes' overall functional status and provide immediate and objective evidence for individualized training and prevention programs. Therefore, this study adopted a cross-sectional design to explore the correlations among selected FMS test scores, pain indices, and fundamental physical fitness performance in elite female softball athletes.

## **2. Participants and Methods**

### **2.1 Participants**

The study focused on the relationships among functional movement quality, pain, and fundamental physical fitness performance in elite female softball athletes. Thirty elite female softball athletes were recruited as participants (basic information is shown in Table 1–Table 2). Among them, 10 were international-level elite athletes and 20 were national-level elite athletes.

The average age was (25.03±4.61) years, and the average training experience was (12.99±4.77) years. All athletes provided informed consent to participate in this testing.

**Table 1. Descriptive Statistics of Athlete Levels**

Athlete Level	n	%
National-Level Elite	20	66.70%
International-Level Elite	10	33.30%

**Table 2. Descriptive Statistics of Athletes' Basic Information**

Variable	Minimum	Maximum	Mean ± SD	Median (M)	Interquartile Range
Age (y)	17	35	25.03 ± 4.61	25.50	2.70
Height (cm)	162	180	169.97 ± 4.43	170.00	7.27
Weight (kg)	56.5	93.4	67.98 ± 8.84	65.50	9.55
Training Years (y)	5.5	22	12.99 ± 4.77	12.10	5.65

**2.2 Methods**

**2.2.1 Testing content**

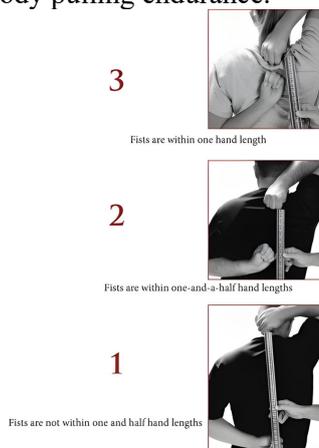
Anthropometric measurements included measuring or recording athletes' height, weight, age, and related indicators.

For functional movement screen, three FMS movement patterns highly relevant to the sport were selected: shoulder mobility (Figure 1), active straight leg raise (Figure 2), and deep squat (Figure 3). The scoring criteria for each test were as follows: 3 points (high-quality completion without compensation), 2 points (low-quality or compensated completion), 1 point (unable to complete the basic movement), and 0 points (pain occurred during testing). For bilateral tests, if asymmetrical scores appeared, the lower score was recorded according to the FMS scoring protocol. In addition, based on athlete and sport characteristics, ankle mobility testing (Figure 4) was included in the study. For statistical convenience, the three grading levels of "green (rear knee passes the inner ankle of the front foot), yellow (rear knee aligned above the inner ankle of the front foot), and red (rear knee does not reach the inner ankle of the front foot)" were quantified as 3, 2, and 1 points respectively, and any pain during testing was recorded as 0 points.

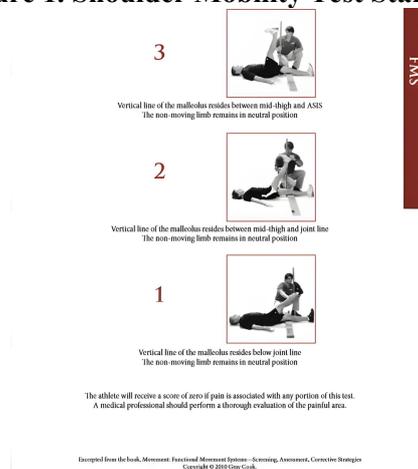
Pain status was assessed using the NRS pain rating scale, with athletes self-reporting pain intensity in six body regions: shoulder, elbow, wrist, lower back, knee, and ankle. A score of 0 indicated no pain, 1–3 indicated mild pain, 4–6 indicated moderate pain, and 7–10 indicated severe pain.

Fundamental physical fitness tests included standing long jump to assess lower-limb explosive power, a 30 m sprint to assess acceleration ability, a 3000 m run to assess aerobic endurance, bench press (1RM) to assess maximal upper-body strength, relative strength (bench press load/body weight), and inverted

row (maximum repetitions in 1 minute) to assess upper-body pulling endurance.



**Figure 1. Shoulder Mobility Test Standard**



**Figure 2. Active Straight Leg Raise Test Standard**

Rating	Reference Photographs	Testing Criteria
3		<ul style="list-style-type: none"> <li>- Upper torso is parallel with tibia or toward vertical</li> <li>- Femur is below horizontal</li> <li>- Knees are aligned over feet</li> <li>- Dowel is aligned over feet</li> </ul>
2		<ul style="list-style-type: none"> <li>- Upper torso is parallel with tibia or toward vertical</li> <li>- Femur is below horizontal</li> <li>- Knees are aligned over feet</li> <li>- Dowel is aligned over feet</li> <li>- Heels are elevated</li> </ul>
1		<ul style="list-style-type: none"> <li>- Tibia and upper torso are not parallel</li> <li>- Femur is not below horizontal</li> <li>- Knees are not aligned over feet</li> <li>- Lumbar flexion is noted</li> </ul>
0	Participant receives a score of zero if pain is associated with any portion of the test.	

**Figure 3. Deep Squat Test Standard**



**Figure 4. Ankle Mobility Test Standard**

To reduce measurement error, all tests were conducted at the same training base. A standardized 10–15 min warm-up (jogging, dynamic stretching, and sport-specific activation) was performed before testing. The testing order followed “functional movement screen—physical fitness testing,” and all athletes completed familiarization trials. Each FMS test was independently scored by qualified assessors. In physical fitness testing, the best value from three valid standing long jump attempts was recorded; the best time from two 30 m sprint trials was recorded; the bench press 1RM was determined using a progressively increasing load protocol with  $\geq 3$  min rest between sets; and both the 3000 m run and inverted row were recorded according to standardized commands and valid repetition criteria. High-load tasks targeting the same muscle group were not arranged consecutively. All data were entered and verified independently by two researchers, and any abnormal values were cross-checked with the original records for confirmation.

### 2.2.2 Data analysis

All collected data were analyzed using Jamovi 2.3 software. Since FMS scores are ordinal categorical variables, Spearman rank correlation analysis was used uniformly to examine correlations among variables.

## 3. Test Results

### 3.1 FMS Score Distribution

As shown in Table 3, athletes demonstrated relatively high performance quality in the active straight leg raise, with 18 athletes achieving a score of 3. In the ankle mobility test, only one athlete reached the 3-point standard, and one athlete reported pain. In the shoulder mobility test, only eight athletes achieved a score of 3, while 11 athletes reported pain during testing, indicating that the shoulder is a high-incidence pain site among softball athletes.

**Table 3 Distribution of FMS Scores Across Test Items (N=30)**

Test Item	3 Points	2 Points	1 Point	0 Points
Ankle Mobility	1	20	8	1
Shoulder Mobility	8	9	2	11

Deep Squat	6	12	10	2
Active Straight Leg Raise	18	7	5	0

### 3.2 Fundamental Physical Fitness Test Results

In lower-limb explosive power and speed-related tests, the average standing long jump performance was  $(217.0 \pm 5.5)$  cm, and the average 30 m sprint time was  $(4.72 \pm 0.21)$  s. Regarding endurance performance, the average 3000 m run time was  $(14.7 \pm 0.23)$  min. For upper-body strength testing, the absolute bench press strength was  $(57.47 \pm 7.75)$  kg, with a relative strength coefficient of  $0.86 \pm 0.11$ . The average number of repetitions in the inverted row test was  $(22.18 \pm 6.49)$  (see Table 4). It is noteworthy that the standard deviations of both the bench press and inverted row tests were relatively large, indicating considerable individual differences in strength performance among athletes.

**Table 4. Fundamental Physical Fitness Test Results (N=30)**

Test Item	Mean $\pm$ SD
Standing Long Jump (cm)	$217.0 \pm 5.5$
3000 m Run (min)	$14.7 \pm 0.23$
30 m Sprint (s)	$4.72 \pm 0.21$
Bench Press (kg)	$57.47 \pm 7.75$
Relative Bench Press Strength Coefficient	$0.86 \pm 0.11$
Inverted row (repetitions)	$22.18 \pm 6.49$

### 3.3 Summary of Athletes' Pain Reports

Among the 30 athletes surveyed, a total of 27 pain reports were recorded (see Table 5). Shoulder joint pain occurred most frequently (11 cases), with an average pain index of 6, indicating moderate intensity. This was followed by lower back pain (5 cases), with an average pain index of 5.2, also indicating moderate intensity. Four cases each reported knee and elbow pain, with the average knee pain index slightly higher than that of the elbow. Only one athlete reported ankle joint pain, but the pain index was relatively high at 7.0, representing severe pain.

**Table 5. Summary of Pain Reports**

Pain Site	Number of Reports	Average Pain Index [Score (Range)]
Lower Back	5	5.2 (4–6)
Knee Joint	4	5.5 (5–6)
Elbow Joint	4	4.3 (3–6)
Shoulder Joint	11	6.0 (5–7)

Wrist Joint	2	4.5 (4-5)
Ankle Joint	1	7.0 (7)
Total/Average	27	5.45

#### 4. Correlation among Variables

##### 4.1 Internal Correlations within FMS

A significant moderate positive correlation was observed between ankle mobility scores and deep squat scores ( $r=0.562$ ,  $p<0.001$ ), indicating that athletes with better ankle mobility demonstrated higher-quality deep squat performance. No other significant correlations were observed among the remaining FMS items. Detailed results are shown in Table 6.

**Table 6. Correlations among FMS Scores (Correlation Coefficient r)**

Item	Ankle Mobility	Shoulder Mobility	Deep Squat	Active Straight Leg Raise
Ankle Mobility	1			
Shoulder Mobility	0.102	1		
Deep Squat	0.562***	0.140	1	
Active Straight Leg Raise	-0.005	0.110	0.268	1

Notes: \*\*\* $p<0.001$

##### 4.2 Correlation between Total Pain Index and FMS

As shown in Table 7, correlation analysis between total pain index and corresponding

FMS scores among the 27 athletes reporting pain indicated that athletes with higher overall pain levels tended to have lower deep squat and shoulder mobility scores, and these correlations were statistically significant.

**Table 7. Correlation between Total Pain Index and FMS Scores (N=27)**

FMS Item	r with Total Pain Index
Ankle Mobility	-0.214
Shoulder Mobility	-0.421*
Deep Squat	-0.387*
Active Straight Leg Raise	-0.198

Notes: \* $p<0.005$

##### 4.3 Internal Correlations among Fundamental Physical Fitness Indicators

Standing long jump performance showed a significant negative correlation with 30 m sprint time ( $r=-0.563$ ,  $p<0.001$ ), indicating that greater explosive power was associated with faster short-distance speed. The 3000 m run time showed a significant positive correlation with 30 m sprint time ( $r=0.593$ ,  $p<0.001$ ), suggesting that athletes with better aerobic endurance also demonstrated relatively better speed performance. Absolute bench press strength was highly positively correlated with relative strength ( $r=0.646$ ,  $p<0.001$ ). Inverted row performance was negatively correlated with 30 m sprint time ( $r=-0.384$ ,  $p<0.01$ ) and 3000 m run time ( $r=-0.429$ ,  $p<0.001$ ), and weakly positively correlated with relative bench press strength ( $r=0.29$ ,  $p<0.05$ ). Detailed results are shown in Table 8.

**Table 8. Correlation Analysis among Fundamental Physical Fitness Test Results**

Item	Standing Long Jump	30 m Sprint	3000 m Run	Bench Press	Relative Bench Press Strength	Inverted row
Standing Long Jump	1					
30 m Sprint	-0.563***	1				
3000 m Run	-0.246	0.593***	1			
Bench Press	-0.138	0.108	0.205	1		
Relative Bench Press Strength	0.109	-0.286*	-0.269*	0.646***	1	
Inverted row	0.075	-0.384**	-0.429***	0.168	0.29*	1

Note: \* $p<0.05$ , \*\* $p<0.01$ , \*\*\* $p<0.001$

##### 4.4 Correlation between FMS Scores and Fundamental Physical Fitness Performance

Overall, the correlations between FMS scores and physical fitness performance were relatively weak (see Table 9). Among the FMS items, shoulder function scores showed a significant positive correlation with bench press

performance ( $\rho=0.446$ ,  $p=0.029$ ), indicating that athletes with higher shoulder mobility and stability tended to demonstrate better maximal upper-body strength. This suggests that shoulder function may play an important supporting role in pushing-type strength movements. The correlation strength was moderate and held practical significance. No other FMS items

showed statistically significant correlations with fundamental physical fitness indicators ( $p > 0.05$ ).

**Table 9. Correlations between FMS Scores and Fundamental Physical Fitness Test Results ( $\rho$ )**

Item	Standing Long Jump	30 m Sprint	3000 m	Bench Press	Relative Strength Coefficient	Inverted row
Deep Squat	-0.127	0.121	0.221	0.118	-0.041	0.198
Ankle Mobility	0.013	-0.003	-0.142	-0.247	-0.376	0.230
Shoulder	-0.305	0.165	0.362	0.446*	0.316	-0.281
Active Straight Leg Raise	0.151	-0.021	0.282	0.134	0.023	0.135

Note: \* $p < 0.05$

## 5. Discussion

Based on the investigation results of elite female softball athletes, this study systematically analyzed the relationships among functional movement quality, pain status, and fundamental physical fitness performance.

Regarding internal relationships within functional movement patterns, a significant positive correlation was found between ankle mobility and deep squat performance, indicating that ankle dorsiflexion mobility plays a key role in fundamental lower-limb movement patterns. Limited ankle mobility may lead to compensatory adjustments in the knees, hips, and trunk during the squat movement, thereby reducing movement quality and increasing injury risk. The findings further confirm the importance of ankle mobility within the lower-limb kinetic chain. Therefore, ankle joint function should be considered a priority in movement assessment and training interventions for softball athletes.

A negative correlation trend was observed between athletes' pain status and functional movement quality, particularly between the total pain index and shoulder mobility as well as deep squat scores, which reached statistical significance. This suggests that pain may influence neuromuscular control, sensory feedback, and movement confidence, thereby inducing or exacerbating compensatory movement patterns and leading to lower FMS scores. Although the cross-sectional design cannot determine causal relationships between pain and reduced movement function, these findings provide practical value for integrating pain assessment with functional movement screen, which may help identify individuals with potential functional impairments at an early stage.

Regarding internal relationships among fundamental physical fitness variables, the study found a significant positive relationship between lower-limb explosive power and short-distance

speed, and a significant positive relationship between aerobic endurance and speed performance. These findings indicate that physical fitness qualities in elite softball athletes do not develop in isolation but demonstrate a certain degree of coordination. Furthermore, the positive relationship between inverted row performance and running performance suggests that posterior upper-body chain strength endurance may play a potential role in maintaining running posture stability and movement economy.

With respect to the relationship between functional movement quality and fundamental physical fitness performance, apart from the significant positive correlation between shoulder function scores and bench press performance, no significant correlations were observed between other FMS scores and physical fitness indicators. This may indicate that FMS primarily reflects athletes' movement control ability, joint functional status, and coordination, rather than directly predicting physical fitness levels.

Additionally, this study has certain limitations, including a relatively small sample size and the adoption of a cross-sectional research design, which prevents causal inference among variables. Future studies should expand sample sizes and adopt longitudinal tracking or intervention-based designs to further examine the dynamic relationships among functional movement screen, pain management, and physical fitness development.

## 6. Conclusions and Recommendations

### 6.1 Conclusions

A significant moderate positive correlation was found between ankle mobility and deep squat performance in elite female softball athletes, indicating that lower-limb joint mobility is an important factor influencing the quality of fundamental movement patterns. Athletes' pain status showed a negative correlation trend with

functional movement quality, with the total pain index demonstrating statistically significant relationships with shoulder mobility and deep squat scores, suggesting that pain may be associated with reduced movement control ability. Specific correlation structures were observed among fundamental physical fitness components, with upper-body strength, lower-limb explosive power, speed, and aerobic endurance showing coordinated relationships. No significant correlations were found between most FMS scores and fundamental physical fitness performance, indicating that functional movement quality and physical fitness performance may represent relatively independent evaluation dimensions, reflecting athletes' functional status and physical capacity respectively.

## 6.2 Recommendations

(1) Establish a multidimensional athlete assessment system. It is recommended to integrate functional movement screen, pain assessment, and physical fitness testing into training monitoring in order to form a systematic athlete condition evaluation framework, enabling comprehensive identification of movement dysfunction, pain risk, and physical fitness limitations.

(2) While improving lower-limb explosive power and speed capacity, maintaining a necessary aerobic endurance base is recommended. Upper-body strength training should emphasize the balance between relative strength and power output efficiency. Posterior upper-body chain strength endurance training may be incorporated as a regular component to enhance movement stability and exercise economy.

(3) Strengthen long-term monitoring and longitudinal research. Future studies may establish long-term athlete monitoring databases and adopt longitudinal or intervention-based designs to explore the effects of functional movement improvement and pain management on physical fitness performance and injury prevention.

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