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EXAMINING OF THE CORRELATION BETWEEN THE FUNCTIONAL MOVEMENT SCREEN AND THE CARDIO FITNESS TEST IN STUDENTS STUDYING IN THE FACULTY OF SPORTS SCIENCES

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Abstract:
This study was conducted to examine the correlation between the scores of the Functional Movement Screen (FMS) and the scores of the Cardio Fitness Test (CFT) in students studying in the Faculty of Sports Sciences. The sample group was composed of totally 25 students, including 14 males and 11 females aged between 22-24 years. The Functional Movement Screen (FMS) test battery including seven stations as deep squat, hurdle step, in-line lunge, shoulder mobility, active straight-leg raise, trunk stability, and rotary trunk and the Cardio Fitness Test (CFT) battery including six stations as resting heart rate, heart rate recovery, body flexibility, upper body strength, core strength, and lower body strength were applied to the sample group in different days. It was found that there was a statistically significant positive correlation between the total scores of the Functional Movement Screen (FMS) and the total scores of the Cardio Fitness Test (CFT) ($r = 0.60$, $p < 0.001$). While no statistically significant correlation was found between the lower body total scores of the relevant test batteries, there was a statistically significant positive correlation between the upper extremity total scores ($r = 0.48$, $p < 0.05$). Consequently; the significant correlation found between the Functional Movement Screen test battery, used in posture analysis and posture rehabilitation, and

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the Cardio Fitness Test formed the opinion that these two tests can be used in the field in combination. It may be recommended to apply this correlation in larger groups and assess the gender and age differences.

Keywords: physical readiness, posture analysis, prevention

1. Introduction

The prevention of the risk of injury of athletes has great importance for sportive performance. The Functional Movement Screen (FMS) is a valid and reliable test, supported in the literature, for the decreasing sportive performance and the estimated value of injury. It is a test battery that can assess the movement asymmetries and movement pattern limitations in a dynamic and practical way and is used to predict injuries (An et al., 2012; Armstrong and Greig, 2018; Beardsley et al., 2014; Bond et al., 2015; Cengizhan and Eyuboglu, 2017; Bonazza et al., 2016; Cook et al., 2010; Cook et al., 2014; Dorrel et al., 2015, Kraus et al., 2014; Minthorn et al., 2015; Scneiders et al., 2011). FMS was developed by Cook et al., (2006) and has become popular rapidly from its development date to the present (Bonazza Ni Smuin et al., 2016; Cook et al., 2010; Cook et al., 2014).

FMS is composed of 7 individual movement tests including the rotary trunk, trunk stability push-up, active straight-leg raise, shoulder mobility, the in-line lunge, the hurdle step, and deep squat and 3 ranges of motion (An et al., 2012; Bodden et al., 2015; Beardsley et al., 2014; Cook et al., 2010; Dorrel et al., 2015; Kraus et al., 2014). The test is applied for three times and scored in scale ranging between 0 and 3 (Beardsley et al., 2014; Dorrel et al., 2015; Kraus et al., 2014). The score interval in the entire completed section is between 0-21 (Dorrel et al., 2015). The individual scores of each movement are the combination of the possible total 21 final scores (Bodden et al., 2015; Beardsley et al., 2014).

The Cardio Fitness Test (CFT) is a test known as aerobic fitness or cardio including the three main components as cardiovascular, strength and flexibility and shows the fitness of heart. Heart Rate Recovery Time can be controlled by measuring resting heart rate or measuring how the heart rate slows down after exercise. The CFT test battery includes 6 stations: resting heart rate, heart rate recovery, seated flexibility, upper body strength, core body strength, and lower body strength While assessing various fitness tests such as cardiovascular, strength and flexibility, the fitness test results are referred and the location of the result for each test in a plot is found (Scneiders et al., 2011).

The aim of this study is to examine the correlation between the scores of the Functional Movement Screen (FMS) and the scores of the Cardio Fitness Test (CFT) in students studying in the Faculty of Sports Sciences.

2. Method

2.1. Participants

A total of 25 students (14 males and 11 females) studying in the Faculty of Sports Sciences and being aged between 22-24 years voluntarily participated in the study. FMS and CFT test batteries were applied to the sample group in different days.

This research was conducted in accordance with the ethics statement of the committee of Kirikkale University before participation (Decision No: 01/01, Date; 05/01/2017). Written parental permission was also provided for all of the volunteers.

2.2. Measures

2.2.1. Functional Movement Screen (FMS)

The FMS test battery including 7 stations as the deep squat, the hurdle step, the in-line lunge, shoulder mobility, active straight-leg raise, trunk stability push-up, and the rotary trunk was applied. The total scores of the people were obtained by having them perform totally 7 individual movement patterns. Each movement was scored between 0-3. Therefore, the participants had a score between 0-21 points. The scores obtained in each movement were added and the FMS total score of a participant was calculated. For each movement pattern, scoring was performed based on the criteria from the norm table. The functional movement screens of the students were assessed with the help of FMS test kit including hurdle and test strip (Cook et al., 2010).

FMS rating system and kit are fundamental, effective and reliable. If the movement pattern is performed correctly, "3 points" are given; if the movement is performed but this performance includes mistakes, "2 points" are given; if the movement pattern is not performed, "1 point" is given; if pain is felt during a test, "0 point" is given (Beardsley et al., 2014; Dorrel et al., 2015; Kraus et al., 2014). From this point, licensed clinicians proceed to the SFMA (Selective Functional Movement Assessments) and healthcare professionals make a referral for assessment (Cook et al., 2010).

Medical or rehabilitation professionals with backgrounds in the SFMA system will be the most helpful and the most informative in case of pain. If pain is noted and you are not licensed and qualified in the system, a clinician having knowledge about the SFMA represents the referral of choice (Cook et al., 2010).

A. Clearing Tests

Three movement patterns have additional clearing tests—the shoulder mobility, trunk stability push-up and rotary stability. The clearing tests are unlike the seven movement-pattern tests, as they are not graded on the 3—2—1—0 scale. These are reported as positive or painful or negative or non-painful. These tests offer extra insight into dysfunction by looking at key areas where range-of-motion extremes are indicators of poor mobility or stability or both. The shoulder complex and lumbar-pelvic region routinely compensate by giving up some degree of stability when neighbouring body

segments have a reduced mobility. These areas need an extra degree of screening scrutiny. These tests; shoulder mobility movement pattern (impingement clearing test), trunk stability push-up movement pattern (prone press-up clearing test), rotary stability movement pattern (posterior rocking clearing test) (Cook et al., 2010).

Table 1: FMS skore sheet

Test		Raw Score	Final Score	Comments
Deep Squat	L			
	R			
Hurdle Step	L			
	R			
Inline Lunge	L			
	R			
Shoulder Mobility	L			
	R			
Impingement Clearing Test	L			
	R			
Active Straight -Leg Raise	L			
	R			
Trunk Stability Pushup Press-up Clearing Test				
Rotary Stability	L			
	R			
Posterior Rocking Clearing Test				
Total				

As shown in Table 1, FMS raw score is used to determine the scores of right and left sides. The right and left sides are scored in five of the seven tests and these two tests are documented in this field. The final score is used to determine the overall score of the test. For the raw score, the minimum score (each side) is transferred in order to give a final score for the test. A person who receives three points in the right side and two points in the left side receives the last two points. Later, the last score is summed up and used as total score (Cook et al., 2010).

B. Deep Squat Movement Pattern

The student assumes the starting position by placing the instep of the feet in vertical alignment with the outside of the shoulders. The legs should be in the sagittal plane; the elbows should be kept at 90-degree angle and the hand position should be adjusted. The students should slowly set the deepest possible squat position and the head and chest should be directed forward. Three repetitions may be performed but if the first movement complies with the criteria to receive three points, there is no need for another repetition. In case that the criteria to receive three points are not met, the FMS kit should be kept under the heels. 2 points are given when a movement is performed on the FMS kit and 1 point is given when a movement is not performed on the FMS kit (Cook et al., 2010).

C. Hurdle Step Movement Pattern

The tibia height of students is measured before starting the test. Since it can be difficult to find the true joint line between the tibia and femur, the top centre of the tibial tuberosity serves as a reliable landmark. In order to adjust the correct height for the hurdle, students are asked to stand behind the hurdle centre and touch the floor of the hurdle in such a way that their toes are aligned. Students are asked to lift up one of their legs on the hurdle and then put it back to the starting position in order to touch their heel to the floor while keeping their spine stable. The hurdle step should be performed slowly and in a controlled manner. If any of the criteria for a score of three is not achieved, the student receives a score of two. If any of the criteria for the score of two is not achieved, the student gets a score of one point (Cook et al., 2010).

D. Inline Lunge Movement Pattern

The tibia height of a student is obtained by measuring from the floor to the uppermost centre of tibia or by measuring it from the cable height during the hurdle step test. Students put their toe of their foot behind to the starting line of the FMS kit, it is ensured that they put the heel of their foot on the front onto the proper landmark on the kit by using the tibia measurement. The student's hand opposite the front foot should be the hand grasping the dowel at the cervical spine. The other hand grasps the dowel at the lumbar spine. The dowel must maintain its vertical position throughout both the downward and upward movements of the lunge test. To perform the inline lunge pattern, the student lowers the back knee to touch the board behind the heel of the front foot and returns to the starting position. If any of the criteria for a score of three is not achieved, the student receives a score of two. If any of the criteria for the score of two is not achieved, the student receives a score of one (Cook et al., 2010).

E. Shoulder Mobility Reaching Movement Pattern

At first, the hand length of student is determined. Students stand up and fist their hands. The student then simultaneously reaches one fist behind the neck and the other behind the back, assuming a maximally adducted, extended and internally rotated position with one shoulder, and a maximally abducted and externally rotated position with the other. Hands are kept fisted during the test and the distance between the closest two points of the hand is measured. This test is performed for three times bilaterally. If any of the criteria for the score of two is not achieved, this is scored as one (Cook et al., 2010).

F. Clearing Exam

There is a clearing exam at the end of the shoulder mobility test. If pain is produced, a positive (+) is recorded on the score sheet, and a score of zero is given to the entire shoulder reaching test (Cook et al., 2010).

G. Active Straight-leg Raise Movement Pattern

The student lies supine with the arms by the sides, palms up and the head flat on the floor. FMS kit is placed under the knees. Both feet should be in a neutral position and the soles of the feet are perpendicular to the floor. The point between anterior superior iliac spine (ASIS) and the knee joint line is determined with and the dowel is placed perpendicular to the floor. Next, the student lifts the test limb while maintaining the original start position of the ankle and knee. During the test, the opposite knee should remain in contact with the board, the toes should remain pointed upward in the neutral limb position, and the head remains flat on the floor. If malleolus gets ahead dowel, 3 points are given. The test is performed mostly for three times bilaterally. If any of the criteria for three points is not met, students get two points. If any of the criteria for two points is not met, students get one point (Cook et al., 2010).

H. Trunk Stability Push-up Movement Pattern

The student assumes a prone position with the arms extended overhead. During this test, men and women have different start positions. Men begin with their thumbs at the top of the forehead, while women begin with their thumbs at chin level. The thumbs are then lowered to the chin or shoulder level per the scoring criteria.

The knees are fully extended, the ankles are neutral and the soles of feet are perpendicular to floor. Students are asked to push in this position. No oscillation should be observed in the spine during the test, trunk should be lifted as a whole. If students cannot perform a push in the starting position, hands are put down to an easier position. Three points are given if the movement is performed when the hands are at the forehead; two points are given if it is performed at the chin level and one point is given if students cannot complete the movement. The test is performed for three times at most. If any of the criteria for three points is not met, two points are given; if any of the criteria for two points is not met, one point is given (Cook et al., 2010).

I. Clearing Exam

There is a clearing exam at the end of the trunk stability push-up test. If pain is produced, a positive (+) is recorded on the score sheet, and a score of zero is given to the entire shoulder reaching test (Cook et al., 2010).

J. Rotary Stability Movement Pattern

Students take the quadruped position with FMS kit, between their hands and knees on the floor. The board should be parallel to the spine, and the shoulders and hips should be 90 degrees relative to the torso, with the neutral ankles and the soles of the feet perpendicular to the floor. Before starting the movement, hands should be open, thumbs, knees and feet should be in contact with the board. The student should flex the shoulder while extending the same-side hip and knee, and then bring elbow to knee while remaining in line over the board. Spine flexion is allowed as the student brings the knee and elbow together. The movement is performed three times at most and

bilaterally. If students become successful in their first repetition, the test is not repeated. If the criteria for three points are not met, students perform the movement in such a way that shoulders and hips are used crossingly. During this diagonal change, there is no need to align arms and legs to the board but students should touch the elbows and knees (Cook et al., 2010).

K. Clearing Exam

There is a clearing exam at the end of the rotary stability test. If pain is produced, a positive (+) is recorded on the score sheet and a score of zero is given to the entire shoulder reaching test (Cook et al., 2010).

2.2.2. Cardio Fitness Test (CFT)

The CFT test battery including 6 stations as resting heart rate, heart rate recovery time, seated flexibility, upper body strength, core strength, and lower body strength was applied. The points are given based on the criteria, the total score in the category is calculated and the overall fitness score is obtained (Thompson et al.; 2012).

Table 2: CFT Test Results

Cardio Fitness Test	
Fitness level based on Resting Heart Rate	**Beats per minute during rest**
Fit: 5 points	Below 65
Above average: 4 points	65-74
Average: 3 points	75-79
Below average: 2 points	80-84
Unfit: 1 points	85 or higher
Fitness level based on Heart Rate Recovery Time	Beats per minute after 3 minutes stepping and 30 seconds rest
Fit: 5 points	Below 80
Above average: 4 points	80-109
Average: 3 points	110-119
Below average: 2 points	120-139
Unfit: 1 points	140 or above
Flexibility	
Fitness level based on Seated Flexibility	Distance reached in Seated Forward Bend
Fit: 5 points	Past student's toes
Above average: 4 points	Student toes
Average: 3 points	Student ankles
Below average: 2 points	Halfway down student's shins
Unfit: 1 points	Student knees
Strength	
Fitness level based on Upper Body Strength	Press-up reps until ''point of challenge''
Fit: 5 points	Over 20
Above average: 4 points	16-20
Average: 3 points	11-15
Below average: 2 points	6-10
Unfit: 1 points	0-5
Fitness level based on Core Body Strength	Sit-upreps until ''point of challenge''

Fit: 5 points	Over 50
Above average: 4 points	41-50
Average: 3 points	31-40
Below average: 2 points	16-30
Unfit: 1 points	0-15
Fitness level based on Lower Body Strength	**Wall squat reps until ''point of challenge''**
Fit: 5 points	Over 45
Above average: 4 points	31-45
Average: 3 points	21-30
Below average: 2 points	11-20
Unfit: 1 points	0-10
Overall fitness score	
Fit	25-30
Above average	19-24
Average	13-18
Below average	7-12
Unfit	6

As shown in Table 2, "Fit" or "Above average" shows that general fitness is good, for this reason, it is aimed to maintain and increase this condition with "moderate" to "intense" workouts. Average means that fitness is good but it should be better; for this reason, people need to do exercise for 4-6 weeks at "moderate" level to pass the category. "Below average" or "Unfit" should not cause students to feel bad. This information should be motivative and students should start with "gentle" workouts for 6-14 weeks (Thompson et al. 2012).

A. Heart Rate Recovery Time Test

Students adjust the Resting Heart Rate. The student makes a high step up and down step for 3 minutes. The new heart rate is controlled after sitting for 30 seconds22. The HR measurements are obtained using shortwave radio telemetry and heart rate measurement monitor (Polar Heart Rate Monitors, Sport Tester, Kempele, Finland). The Polar HR monitor is composed of the cordon (coded) that is attached to chest and enclosing the rib cage, transmitting HR signals and the receiver watch (Polar Accurex Plus) recording the HR data and worn on the arm. The HR values recorded with Polar Accurex Plus are transferred to computer environment using Polar interface (Thompson et al.; 2012).

B. Upper Body Strength Test

Students stand on all fours on the floor. The palms are put directly on the mat under the head and the hands are placed in the width a bit more than shoulder width. Students move their knees slightly backwards and their necks, backs and upper legs form a straight line by looking down. While breathing, they release their body towards the floor and bend arms and let the elbows to move laterally. It should be performed comfortably and students should wait for a few seconds. While breathing, students push themselves until their arms are flattened. Students perform repetitions as soon as

possible until they move beyond the "Challenging Point". When they do 25-30 repetitions easily, they are tested with a complete push-up (Thompson et al.; 2012).

C. The Core Body Strength Test

Students lie flat and bend their knees. Feet are kept horizontally to the floor and it is moved away from the hip. Hands are fastened on the back of neck and abdomen is withdrawn towards the spine. Students take a breath and exhale for preparation. While students exhale, they lift their heads and shoulders up to a comfortable position and wait for several seconds. While taking breath, they slowly lift themselves down. Students do lots of repetitions until reaching the "Challenging Point". After 60-70 repetitions are done easily, arms are tested as stretched straight over head (Thompson et al.; 2012).

D. The Lower Body Strength Test

Students open their legs in hip width and in parallel position, lean against the wall, and stretch their legs comfortably. They move their foot from the wall slightly and bend their knees at right angle without using their feet. Students take a breath and exhale for preparation. While students take breath, they bend their knees with a proper angle and do a wall sit without a chair. At the same time, they lift their arms up to shoulder length and keep them for a few seconds at this position, then they stand and take a breath while moving back to their position. They do repetitions until reaching the "Challenging Point". After doing 40-50 repetitions easily, legs are tested by being approached slightly after each squat instead of keeping legs completely straight (Thompson et al.; 2012).

E. The Seated Flexibility Test

Students open their legs a bit more than hip width, stretch their feet, and sit. While taking breath, they start to stretch out their arms while their arms are between their legs and one of their hands is over the other hand. While exhaling, they lift up chin to chest and stretch their hand towards the floor. They keep this position for a few seconds. How fingertips reach to knees, ankles and toes and more is tested. 3 repetitions are done (Thompson et al.; 2012).

2.3. Procedure

All measurements were performed at an indoor sports hall of the faculty. Total FMS score was obtained with Deep squat, hurdle step and in-line lunge and total CFT score was obtained with lower body strength. The FMS score was obtained with push up and total CFT score was obtained with the upper body strength. Total FMS scores and total CFT scores were obtained.

2.4. Data analyses

All the data obtained in the study were recorded in SPSS program. Independent samples T test was applied in order to determine whether or not there was a significant difference between FMS and CFT and Pearson correlation test was applied to examine the correlation and the significance level was determined as $p<0.05$.

3. Results

No statistical significant correlation was found between total FMS score and deep squat, hurdle step and in-line lunge, and between total CFT score and lower body strength. A statistically significant positive correlation was found between FMS score and push up, and between total CFT score and upper body strength ($p<0.05$). A statistically significant positive correlation was found between total FMS scores and total CFT score ($p<0.01$).

Table 3: Total FMS And Total CFT, FMS Push And Upper CFT, Total Lower FMS And Lower CFT Independent Sample T-test Results

	N	X	S.S.	sd	t	p
Total CFT	25	15,32	2,193	24	34,927	
Total FMS	25	22,00	4,093	24	26,877	,603 ,001**
Total Lower FMS	25	6,04	1,098	24	27,492	
Lower CFT	25	4,72	,678	24	34,796	,072 ,734
Push CFT	25	2,24	,970	24	11,552	
Upper CFT	25	4,16	1,248	24	16,671	,484 ,014*

*p< 0.05
**p< 0.01

As shown in Table 3, no correlation was found between the lower body strength and the parameters of functional strength analysis measuring the lower extremities ($t(24)=34.80$, $p>0.05$). A direct proportion was found between the upper body strength and the parameters of functional strength analysis measuring the upper extremities ($t(24) = 16.68$, $p<0.05$). As the upper body gained strength, the cardio fitness level of people increased. When total scores are taken into consideration, a positive proportion was found between total scores of the two tests ($t(24) =26.88$, $p<0.01$). There was a linear correlation between total FMS score and total CFT score.

4. Discussion

This study was conducted to examine the correlation between the scores of the Functional Movement Screen (FMS) and the scores of the Cardio Fitness Test (CFT) in students studying in the Faculty of Sports Sciences. According to the FMS and CFT results performed in different days, no significant correlation was found between the lower body strength and functional strength and a significant correlation was determined between the upper body and total scores. There are numerous studies in the literature in which CFT and FMS tests have been applied.

A total of 50 university students including 34 males and 16 females, participated in the study of Zeng et al., in which they examined the Functional Movement Screen (FMS) and Motor Proficiency Test (BOMPT). FMS and Bruininks-Oseretsky Test of Motor Proficiency (BOMPT) were applied. As a result of the study, no significant correlation was found between total FMS and MP scores. A significant correlation was found between the shoulder mobility in FMS and the hand coordination in MP. A significant correlation was found between the active straight-leg raise in FMS and the body coordination in MP (Zeng et al., 2016).

In the study by Chimera et al., to examine the effect of the injury history and gender on FMS and Y balance test, 200 female athletes participated. FMS and Y balance test were applied. As a result, the history of injury and gender factors affected FMS and Y balance test performance (Chimera et al., 2015).

Sixty-two male players aged between 18-32 years participated in the study conducted by Fox et al., to form normative data for FMS in Male Gaelic area sports. FMS test was applied. As a result, the FMS main score for the pattern was 15.56-1.46. The Professional group (15.8-1.58) score was found to be significantly higher compared to the amateur group (15.34-1.31) but no significant difference was found between the groups. No significant correlation was found between age, BMI, height, weight and FMS total scores (Fox et al., 2014).

Twenty-eight healthy male and females participated in the study by Okada et al., to examine the correlation between Performance, FMS, and Core Stability. As a result of the study, significant positive correlations were observed between core stability and performance tests in terms of FLEX, LATr, and LATl in Single Leg Squat (SLS). T-run (TR) showed significant correlations with both LATr and LATl. Significant correlations were found between FMS and performance tests. While BOMP showed positive correlations with Hurdle step right (HSr), push-up (PU) and rotary stability (RSr), BOMP had negative correlations with shoulder mobility (SMr). There was a positive correlation between TR and SMr; whereas TR had a negative correlation with HSr and SMr. No significant correlation was found between the FMS variables and core stability (Okada et al., 2011).

Nine healthy female athletes participated in the study conducted by Lockie et al., to examine the correlation between athletic cardio performance and functional movement screen scores. FMS, bilateral sit and reach test, 20m sprint, jumping,

unilateral sit and reach test, 505 and modified t test were applied. As a result, a positive correlation was found between unilateral sit and reach test and the active leg lift (left leg) and a significant positive correlation was found between the jumping performance and the active leg raise (Lockie et al., 2015).

Sixteen female and 27 male runners participated in the study conducted by Loudon et al., to determine the average value of the functional movement screen in long-distance runners (two groups, younger than the age of 40 and below and older than the age of 40). Running 30 kms and FMS were applied and, as a result, no significant difference was found in the combined scores of the females and males. A significant difference was found between push-up and the active leg raise in terms of gender; whereas, a significant difference was observed between young and old runners (Loudon et al., 2014).

Twenty-five professional footballers participated in the study conducted by Zalai et al., to examine the injury examination and the quality of functional movement patterns in the elite male professional footballers and Yo-Yo intermittent recovery test and FMS were applied for the footballers. As a result, a difference was observed between the players in the segmental body composition and Yo-Yo intermittent recovery test performance (Zalai et al., 2014).

Boguszewski et al., conducted a study to assess the movement patterns of children using FMS in the karate application and 17 female and 45 male karate players have participated in their study. They were divided in the experimental and control groups and the FMS was applied for experimental group. As a result, the experimental group had significant differences compared to the control group in the FMS test results (Boguzewski et al., 2015).

Thirty male footballers participated in the study of Lloyd et al., in which they examined the correlation between the cardio maturation and FMS scores in the young footballers. FMS, squat jump, reactive strength and reactive agility test were applied. As a result, a significant correlation was found in the deep squat, the in-line lunge, active leg raise and rotary trunk tests with all the performance tests; the highest variance was found in the reactive agility and reactive strengthen in-line lunge performance as the powerful predictor of age and squat jump test (Lloyd et al., 2015).

5. Conclusion

Consequently, a statistically significant positive correlation was found between total lower FMS score and lower CFT score ($p<0.01$). Also, a statistically significant positive correlation was determined between the FMS push up and the upper CFT ($p<0.05$). A statistically significant correlation was not found between total lower FMS and total lower CFT. It is recommended to conduct the study with larger groups and by regarding gender and age distinction.

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