

Relationship between Physical Fitness and Functional Movement Screening Scores in Active Males: Providing Preventing Model

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Abstract

Introduction An increasing number of sports injuries and consequences of the injuries suggest that prevention of sports injuries is essential. The first step in the prevention of sports injury is screening, and one of the most critical tools in the field is functional movement screening tests. This study aimed to evaluate the relationship between physical fitness and functional movement screening scores in active males. **Materials and Methods:** This was a correlation study. For execution, 50 active males from Iran, East azerbaijan state, Bonab city (age 22.60 ± 3.09 yr, height 177.70 ± 6.38 cm, weight 74.06 ± 10.12 kg, sports history 11.12 ± 3.73 yr and physical activity per week 8.50 ± 4.52 h) were selected purposefully. The functional movement screening tests include: deep squat, hurdle step, in-line lunge, shoulder mobility, active straight-leg raise, trunk stability push-up, and rotary stability. Flexibility, speed, power, and agility were assessed using sit-and-reach, 20-m sprint, vertical and standing broad jumps, and modified T-test, respectively. **Results:** The results demonstrated that there was a significant correlation between functional movement screening tests, flexibility, and power. However, no significant correlations were found between functional movement screening tests, speed, and agility. Also left leg flexibility and vertical power were significant predictors for functional movement screening tests. **Discussion:** Scores of functional movement screening tests provides the primary injury prevention model for coaches to predict future injury in athletes. Therefore, it is recommended for coaches to pay more attention to the factor of flexibility and vertical and horizontal power to prevent the injuries by considering the specificity principles of training.

Key words: Agility, Flexibility, Functional Movement Screening, Power, Speed

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Introduction

By increasing the participation in sports activities, the number of athletes at the risk of injury has increased. According to the NCAA, about 182,000 injuries have occurred in athletes from 1988 to 2004, and lower limb injuries in the knee and ankle were the most damaging (1). Injuries happen when biomechanical loads are higher than the tolerance (2). Although risk factors can vary between athletes and different sports, these risk factors are associated with the injury mechanisms that may expose athletes to injury. The risk factors related to physical fitness of athletes are essential in prevention since they are highly corrective with specific exercises (3). In addition, the severity of injuries in sports is usually estimated based on the time athletes are away from the

tournament and training sessions. Injuries can affect the performance of athletes, especially if the severity is moderate, severe, or recurrent. Most injuries occurred during the sports can heal and improve with proper rehabilitation exercises. In fact, athletes can continue sports activity as before. However, some injuries may restrict the level of sports; consequently, athletes either cannot play as prior to the injury or they quit their exercise. Also, some injuries can have adverse consequences later in life such as osteoarthritis after severe knee injuries (4, 5). Therefore, injuries should be treated effectively so that it would be possible to do sports activities. The injuries for athletes who are at the championship level need not only to be diagnosed appropriately but also should be entirely treated to re-exercise athletic skills within a short time (6-8).

It is important to identify strengths and weaknesses in sports activities and also to athletes at risk while working with athletes. Considering that high quality of training and prevention of injury are inter-related (2), the emphasis of most fitness and power programs is on improving strength, power, speed, and the ability to shuffle in athletes. Most sports instructors and professionals prescribe programs to improve muscle strength, which in turn reduces the time of sprint shuffling (9). As a result, the primary goal should be to improve the fitness of players, specific techniques and tactics of each sport to reduce the risk of injuries (2). A range of assessments is used to analyze the physical capacity of sports team athletes. These assessments can include linear speed tests (e.g., speed at different intervals), speed of shuffling (e.g., 505 agility test, and T-test), lower extremity strength (e.g., maximum jump), and flexibility (e.g., sit-and-reach flexibility test) (10). Although it is believed that reducing flexibility increases the rate of injuries in sports, limited studies have referred to this correlation (11). Studies have also demonstrated that there is a correlation between vertical jump height and running speed in athletes (12). In addition, most potent athletes can withstand high loads of muscles, tendons, and joints during jumping, shooting, sprint, and shuffling that will increase the biomechanical load on these structures. Several studies have considered foot strength or jumping ability among athletes (13, 14). However, there is little evidence to demonstrate a correlation between foot strength and injury level (3).

Therefore, sports performance tests are used to determine the athlete's current performance level, the effectiveness of the exercise, and the creation of specific sports modalities. Functional Movement Screening tests (FMS) have been described as one of the particular performance predictors of exercise, jump, sprint, and agility (15). Regarding the increase in sports injuries, preseason screening for athletes in competitions and professional sports is prevalent. Screening is performed to prevent injuries and to improve performance strategies.

Cook *et al.* introduced functional movement screening tests based on preseason screening and related factors. The FMS tests consist of seven movement tests that can identify the limitations and variations in natural movement patterns. These tests are designed to determine the interaction between the movement chain and the stability necessary to perform functional and essential movement patterns. This set can be performed within 5 to 10 minutes, therefore, can be easily used by trainers for preseason assessments. This set includes Deep Scott, Hurdle Step, In-line Lunge, Shoulder Mobility, Active Straight-leg Raise, Trunk Stability Push-up, and Rotary Stability (16). On the other

hand, recently, coaches have used movement screening tests as a tool for assessing the athletes' functional ability. FMS has been used to identify impairments that increase the risk of injury. A motor impairment that increases the injury risk can theoretically affect sports performance. This relationship can be of great value to athletes as a means of correcting motor inefficiencies identified by screening tests (10). Mitchell *et al.* (10) reported that static posture is not related to the FMS results; the core strength had a positive correlation with the total FMS score, and over 60% athletes demonstrated at least one asymmetry (17). Parchmann and McBride (15) concluded that there is no significant correlation between FMS and record (time) of the 10-meter sprint, speed, 20-meter sprint, vertical jump height, and agility T-test time. Kiesel *et al.* used FMS tests on national soccer players and gained preseason FMS scores for 46 players; the scores equal or less than 14 in FMS tests positively predict the likelihood of injury with a Sensitivity of 0.54 and a Specificity of 0.91 (18).

In the last 20 years, the willingness has progressed from isolated assessments and strengthened towards functional, integration, and movement control approaches in the area of injury prevention. However, a reference to technical resources is not possible without functional evaluations. In the former sports medicine model, preseason assessments included only assessing the performance of athletes; however, these assessments could not provide the appropriate information for identifying athletes at the risk of injury and their readiness to participate in the activity. The use of injury screening tools has made it possible to identify athletes at risk and has paved the way for developing prevention programs. On the other hand, musculoskeletal injuries over an extended period have several implications such as chronic ankle instability, osteoarthritis, and loss of quality of life, with more severe injuries, decreased physical activity, and increased fear of re-injury in exercise. Therefore, using screening tests can be a significant cornerstone for identifying and preventing chronic injuries.

Also, the financial consequences of injury, such as the cost of surgery and rehabilitation as well as psychosocial factors, have highlighted the need for injury prevention programs. In addition to financial costs, the loss of the entire season and the long-term disability can be the consequences of the injury. Since injuries cause athletes to be away from exercise for a long time and adverse effects are likely to persist; therefore, preseason screening and injury prevention can be crucial (16). Therefore, the present study aims to examine the relationship between physical fitness and functional movement screening scores in active males.

Materials and Methods

The present study was a correlational study. The statistical population included 19-29 active men in sports clubs in Iran, east azerbaijan state, Bonab city. According to the inclusion criteria, 50 subjects were selected using purposeful available sampling. Then, they voluntarily participated in the study.

The measurement tools included two digital video cameras (for analyzing movements), the consent form, demographic questionnaire (for selecting samples with inclusion criteria), Beck's Physical Activity Scale to homogenize the subjects (ranging from 13 to 15 to determine active people), wooden bar, hurdle, 2×6 mattress (for performing functional movement screening tests), weight (for measuring the weight of the subjects), height scale (for measuring the height of the subjects), sit-and-reach box (for measuring flexibility), stopwatch, band meter, and cone-shaped markers.

The inclusion criteria were:

- 19 to 29 years old active men
- No history of injury in the trunk and lower limbs during the last year (19)
- No history of pain or surgical in the trunk and lower limbs(16)
- No excessive joint laxity (examination using the Beighton score)(16)

The tests were conducted for two months at three separate sessions. The first session included FMS tests. The FMS test procedure was described completely to the subjects, and then FMS tests were performed using the wooden bar, hurdle, and 6×2 mattresses. Each subject completed three trials for each condition, and the best trial from each condition was analyzed. The subjects were relaxed for five seconds between attempts and one minute between trials. Subsequently, the FMS test scores were determined by observing the films recorded by two camcorders from both the anterior and side views during the trials. The flexibility of the two legs, the strength and speed of the subjects was measured in the second session. In the third session, the flexibility of the right and left legs, as well as the agility of the subjects, was measured. The assessment sessions lasted 30 to 60 minutes. At the beginning of the first session, the height and weight of the subjects were measured. In the second and third sessions, 10 minutes of warm-up, including jogging, were considered before performing the tests. Each test was repeated three times and scored the best performance (10).

Functional Movement Screening tests

Each subject was assessed by its performance in seven functional movements, including deep squat, hurdle step, inline lunge,

shoulder mobility, active straight-leg raise, trunk stability push-ups, and rotary stability. The FMS is comprised of seven separate tests, and each test is ranked with a score from zero to three with a high score corresponding to proper movement. A score of three indicates the movement is complete, a score of two demonstrates some level of compensation, a score of one suggests the pattern is incomplete, and a score of zero indicates pain is present. The subjects complete five of the seven tests (hurdle step, inline lunge, shoulder mobility, active straight-leg raise, and rotary stability) on both the right and left sides of their body and receive a score for each side. Note that differing scores indicate an asymmetrical movement pattern and may lead to an injury. The total scores from each test were added together to obtain a composite score. Therefore, a subject can receive a minimum composite score of zero (if the pain is present in every movement test) and a maximum composite score of 21 (if the subject scores a three on every test) (20). Teyhen *et al.* reported moderate to good intratester and intertester reliability for these tests (21). Chorba *et al.* also reported this test is a sufficiently reliable estimate of injury, so that a score <14 in this test would make the athlete four times more likely to go through an injury (22).

Clearing Exams

Clearing exams are separate from the tests and are utilized to identify a pain response. The clearing exams include the impingement clearing exam, press-up clearing exam, and posterior rocking clearing exam corresponding to the shoulder mobility test, trunk stability pushup test, and rotary stability test, respectively. Clearing exams are performed after the corresponding movement tests. When pain is present during a clearing exam, a positive (+) score is recorded, and the subject receives a zero for the total score of that similar test.

These exams provide additional information on movement dysfunction by using a range of motion extremes to identify possible poor mobility and stability (20).

Sit-and-reach

The sit-and-reach is a field test used to assess overall flexibility of the subject, back muscles, and hamstring muscle group. A sit-and-reach box with a scale marked on the upper side was placed against a wall. Subjects removed their shoes and with their legs extended, placed the soles of both feet inside the box. The subject positioned their hands on top of each other (tips of the middle fingers aligned), with the palms down. The subject then reached slowly forward and touched as far as possible along the scale, and held this position for 5s. The point where the tip of the middle fingers touched the distance measured by the scale, and the best trial was used.

For the unilateral sit-and-reach, the subjects sat at the sit-and-reach box and fully extended one leg so that the foot was flat against the end of the box. Subjects then bent the other leg so that the foot was flat on the floor with the knee and hip flexed at approximately 90° and 45°, respectively. Subjects positioned their hands on top of each other with the palms down, reached forward and touched as far along the scale as possible while not flexing at the extended knee, and held this position for 5s. Both legs were assessed, and the best trials were used.

20-meter Sprint

This test was used to measure the speed of a subject in the sprint. A 20-meter track was marked with cones placed on the hall surface. Subjects began the sprint from a standing start 30 cm behind the start line to trigger the first gate (a verbal command plus a visual action such as rapid hand-raising) and quickly passed through the 20 meters gate and the stopwatch was stopped. Subjects completed three trials, with three min recovery between each trial, and the fastest trial was used for the analysis.

Vertical Jump (Sargent Jump)

The vertical jump provided an indirect measure of vertical plane leg power. A Yardstick device measured jump performance. The subject stood side on to the Vertec (on the subjects' dominant side), and while keeping their heels on the floor, reached upward to displace as many vanes as possible. The last vane moved was recorded as the standing reach height. The bilateral jump involved the subject jumping as high as possible using a two-foot take-off with no preparatory step, with no restrictions placed on countermovement range of motion. Height was recorded in cm from the highest vane moved, and vertical jump height was calculated by subtracting the standing reach height from the jump height. Following the bilateral jumps, subjects completed unilateral jumps in the same manner for both legs, the order of which was randomized between subjects. Subjects took off from one leg and landed on both feet. Each subject completed three trials for each condition, with two min recovery between trials. The best trial from each condition was analyzed.

Standing Broad Jump

The standing broad jump indirectly measured horizontal power. The subject placed the toes of both feet on the back of the start line. With a simultaneous, unrestricted arm swing and crouch, the subject leaped forward as far as possible, ensuring a two-footed landing. Subjects had to 'stick' the landing; if not, the trial was disregarded, and another trial was performed. The distance was measured perpendicularly from the front of the start line to the posterior surface of the heel at the landing. Three trials were

completed for each condition. Two min between-trial recovery was allocated, and the best trial for each condition was used.

Modified T-Test

The T-test incorporates team sport-specific movements such as sprint accelerations, decelerations, lateral shuffling, and backpedaling. A modified T-test with shorter distances was used. Markers were positioned as shown in Figure 2, with a start line identified by tape on the floor, and one, 1.2-m high timing gate. Subjects sprinted 5-m forwards to touch the top of the middle marker. They then side-shuffled 2.5-m to the left or right, depending on the trial, for reaching the next marker, side-shuffled 5-m in the opposite direction to touch the next marker, side-shuffled 2.5-m back to reach the middle marker again, before back-pedaling past the start line to finish. The hand that was on the same side as the shuffle direction (left hand when shuffling to the left, right hand when shuffling to the right) was used to touch the marker. Six trials were completed; three with movement initiation at the middle marker to the left, and three to the right. The order of trials was randomized, three min rest was allocated between trials, and the best trial from each condition was used (10).

Descriptive statistics including mean and standard deviation were used for data analysis. Also, Spearman correlation coefficient test has been used to determine the relationship between functional movement screening tests and flexibility, speed, power, and agility. Moreover, multivariate regression test was used to predict the correlation between functional movement screening tests and the variables of flexibility, speed, power, and agility. All the analyses were performed using SPSS software version 22 at a significant level of 0.05.

Results

The demographic characteristics of the subjects are listed in Table 1. The Kolmogorov-Smirnov test was used to evaluate the normal distribution of the data. Considering that the Kolmogorov-Smirnov test results in the functional movement screening scores ($P=0.0001$) have an abnormal distribution, the Spearman correlation coefficient test was used to examine the relationship between the scores and the studied variables. The findings demonstrated that there is a significant positive correlation between functional movement screening and two-leg flexibility, right and left leg flexibility, vertical and horizontal power of active males. However, there is no significant relationship between functional movement screening scores, speed, and agility (Table 2).

Table 1. Demographic characteristics of subjects (n = 50)

Age (Years)	Height (Centimeters)	Weight (Kg)	Sports Experience (years)	Physical activity per week (hours)
22.60±3.09	177.70± 6.38	74.06±10.12	11.012±3.73	8.50±4.52

Table 2. Relationship between functional movement screening scores and physical fitness variables (n=50)

Variable	Correlation coefficient	Sig	95% Confidence level	
			Lower Bound	Upper Bound
Flexibility of both legs	0.375	*0.007	0.108	0.591
Flexibility of right leg	0.402	*0.004	0.14	0.611
Flexibility of left leg	0.420	*0.002	0.161	0.625
Speed	-0.210	0.144	-0.461	0.072
Vertical power	0.416	*0.003	0.156	0.622
Horizontal power	0.316	*0.026	0.042	0.546
Agility	-0.258	0.070	-0.5	0.021

*: Significant at 0.05

Table 3. Results of stepwise regression of predictor variables on the criterion variable

Step	Predictor	R	R ²	df	F	B	Beta	t	Sig
First	Flexibility of left leg	0.471	0.222	48	13.672	0.165	0.471	3.698	*0.001
Second	Flexibility of left leg Vertical Power	0.572	0.327	47	11.413	0.140	0.398	3.247	*0.002
						0.146	0.332	2.710	*0.009

*: Significant at 0.05.

The results of linear regression in Table 3 indicate that among all variables, left leg flexibility plays the most critical role in determining the functional movement screening scores. In the first step, the flexibility of the left leg explains 22.2% of the variance of functional movement screening scores. F-test for the significance of the correlation coefficient was 13.672, which is significant at the level of 0.001. In the second step, the flexibility of the left leg and vertical power explain in total 32.7% of the variance of functional movement screening scores, and F-test for the significance of the correlation coefficient is 11.413, which is significant at the level of 0.002.

The linear regression equation in the first model, where only the left leg flexibility is considered, is as follows:

$$\text{FMS} = 0.165 (\text{Left Leg Flexibility}) + 10.472$$

Furthermore, the linear regression equation in the second model, where the flexibility of the left leg and vertical power are considered, is as follows:

$$\text{FMS} = 0.146 (\text{vertical power}) + 0.140 (\text{Left Leg Flexibility}) + 3.951$$

Also, none of the predictor variables of two-leg flexibility, right foot flexibility, speed, horizontal power, and agility were considered in the model and could not predict the criterion variable (functional movement screening scores) significantly.

Discussion

The aim of the current study was to determine the relationship between physical fitness and functional movement screening scores in active males. Most of the regular activities require some flexibility. Most people believe that good flexibility is essential in preventing musculoskeletal injuries. They usually perform stretching exercises in the form of a warm-up program before engaging in intense physical activity (23). On the other hand, it is necessary to have a reasonable level of fitness for high-level competition. Flexibility and agility are both critical parameters of fitness for athletes to be selected for any match (24). Stretching is accepted as an integral part of an exercise to reduce the risk of injury and improve sports performance (25). Cook *et al.* have introduced functional movement screening tests about preseason screening and related factors (16) and stated that the in-line lunge and hurdle step requires the flexibility of the hip muscles. The active straight-leg raise assess the flexibility of the hamstring, gastrocnemius, and soleus (10). The probable cause of the relationship between flexibility and functional screening tests can be attributed to lunge tests, step-ups, and lift-ups that require flexibility. Therefore, it seems that subjects who scored more points in sitting and bending tests scored higher in lunge trials, barrier stroke, foot lift, and overall score. The results of the present study are consistent with the

results of Lockie *et al.* (10), that there is a positive correlation between the flexibility of the right leg, left leg, left lunge, and active straight-leg raise and the total score.

In the case of FMS, the trend implies having better overall functional movement patterns and functional stability contributes to better speed/agility of performance. Having a proper range of motion at the ankle, knee, and hip is essential for sprinting efficiently. Limitations in range of motion could alter an individual's mechanical advantage during an all-out sprint and hinder performance (26). Cook *et al.* stated that the in-line lunge and hurdle step requires the flexibility of the hip muscles. The active straight-leg raise assess the flexibility of the hamstring, gastrocnemius, and soleus. However, each of these screens is performed slowly, from positions atypical to team sports. Also, higher flexibility, and by extension higher musculotendinous compliance, may compromise power-based activities such as sprinting. As an example, higher musculotendinous compliance has been connected to increased 20-m sprint time in track sprinters (10). The results of this study are consistent with the results of Lockie *et al.* (10), Parchmann and McBride (15), that there is no significant correlation between FMS scores and speed.

The highest score in the active leg-raise test was associated with the weakest performance in the jump test. Therefore, the subjects who scored three at the active leg-raise test were weaker at jumping test. The trunk stability push-up involves the maintenance of a stable trunk, which should allow for force transition through the body into the upper extremities. A vertical jump requires a strong core, to allow traveling of the force generated by the legs into the upper body. The trunk stability push-up may indicate core stability that could assist with between-leg balance in vertical jumping for females (10).

The positive association of FMS and VJ can be explained by the similarity of the squat portion of the FMS test and the VJ. The vertical jump utilizes the squatting motion to generate momentum vertically as seen in the deep squat portion of FMS testing (26).

Those who can perform the deep squat motion are capable of providing the momentum and range of motion necessary for the vertical jump (26). The results of this study are consistent with the results of Lockie *et al.* (10), indicating that there is a significant correlation between functional movement screening scores and power. However, the results of research by Parchmann and McBride (15) showed that there is no significant correlation between functional movement screening scores and power. This inconsistency is likely to be due to the gender of the subjects, their level of activity or type of sport because the subjects of the Parchmann and McBride's (15) research were

male and female golfers. Among the components that can predict the functional movement screening tests; the highest modified coefficient (beta) was in the first model between "left leg flexibility" and "functional movement screening tests." However, the lowest effect size was in the second model between "vertical power" and "functional movement screening tests." The low effect size between vertical power and functional movement screening tests can be due to the speed component of power. On the one hand, the speed component was not a significant predictor for the criterion variable due to the probable effect of the type of muscle fibers. Since the power factor is a combination of power and speed. Therefore, determining the predictive power of each physical fitness factors for functional movement screening tests and the role that flexibility, speed, power and agility play in the successful performance of athletes, it is advisable for coaches in the preseason exercises to pay special attention to these factors (flexibility and power) and strengthen them to enhance physical fitness and prevent injuries.

Another functional test related to power is a horizontal jump that is different from the vertical jump because stability in the landing stage is a large part of the desired performance (26).

Taller persons have a better horizontal jump, which may be due to their ability to move their mass center. Tall people are easily able to move the center of their mass which can help their jump length. The mass center of tall people is more distant from the ground than short people, which is an advantage for the jump length. The length of tall people's body can be utilized in the horizontal jump. Also, tall people have longer arms that can be used to produce greater horizontal horse (26).

The results of this study are consistent with the results of Lockie *et al.* (10), showing that there is a significant correlation between functional movement screening scores and power. But the results of research by Parchmann and McBride (15) showed that there is no significant correlation between functional movement screening scores and power. This inconsistency may be due to the gender of the subjects, their level of activity or type of sport because the subjects of the Parchmann and McBride's research were male and female golfers (15).

Given the fact that stability is necessary while shuffling quickly and plays a crucial role in the modified T-test. The limitation in core stability or in the range of thigh or knee motion can affect the function of the individual when performing lateral shuffling and touch the line on the ground at maximum speed. Having appropriate stability and range of motion will put individuals in a better position to run and function at a high level (26). The results of this study are consistent with the results of Parchmann and McBride (15) that

there is no significant correlation between functional movement screening scores and agility scores. However, Lockie *et al.* (10) reported that there is a correlation between functional movement screening scores and the time of lateral shuffling, are inconsistent with the current study. This inconsistency is likely to be due to the gender of the subjects, their level of activity or type of sport because the subjects of the Parchmann and McBride's research were athletic women who entertainingly exercised (15).

Considering that performance evaluation in the new models of injury prevention is based on two screening approaches before the tournament and returning to exercise after injury, it is necessary for coaches and sports practitioners to record functional score and screening of athletes before the season. It is better to assess these two factors in stages, and if they find an inappropriate correlation between the variables, they have to prevent injury in consultation with the medical officer and the team's bodybuilder coach. Also, for those athletes who have been injured, assessing and examining the relationship between them can be a fundamental step for observing the athlete's progress in returning to exercise after the injury.

Therefore, the functional movement screening tests provide a primary injury prevention model for the coaches to predict the incidence of injury in athletes. It is necessary for sport teams' coaches to utilize functional movement screening tests as a valid instrument along with medical tests, and measure the functional level of their athletes; so that before the start of the tournament, the ability of each athlete and those at risk would be identified to improve their physical fitness (especially flexibility and power) according to the principle of specificity.

In addition, a significant factor in injury prevention and performance improvement is the rapid determination of mobility and stability deficiencies. The defect in these two factors causes a change in the motor chain. Assessment using screening tests considers the entire motor chain and identifies damaging compensatory movements in the motor chain. Therefore, due to lack of the studies in this field, the present study is considered as a preliminary. The relationship between variables and other tests should be further examined in future studies, and useful information will be provided.

Conclusion

According to the results of this study, there was a significant positive correlation between functional motion screening and two-leg flexibility, right and left leg flexibility, vertical strength, and horizontal power of active men. Also, among all variables,

left leg flexibility played the most important role in determining the functional movement screening scores. Therefore, according to the findings of this study, the sports coaches are recommended to take into account the specificity of training, the flexibility factor, and the vertical and horizontal power to prevent injuries.

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Conflict of interest:

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All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

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