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Relation Y-Balance Test and Lower-limb Strength of Sport Science Faculty Students at the Arab American University

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Abstract

The purpose of this study was to elucidate the relationship between the Y-balance test (YBT) distance and the lower-limb strength of Sport Science Faculty students at Arab American University. Forty (40) collegiate students aged (19.80 ± 1.26) years, enrolled in the second semester of the 2022-2023 academic year from the sports science department, volunteered for this study. The participants underwent MMT (Manual Muscle Testing) to evaluate the maximum muscle strength of the lower limbs, including hip flexion, hip extension, hip abduction, hip adduction, hip internal rotation, hip external rotation, knee flexion, knee extension, ankle dorsiflexion, and ankle plantar flexion). Additionally, they performed the Y-Balance Test (YBT) evaluations in the anterior, posteromedial, and posterolateral directions. An independent sample t-test was used to compare the means between two groups, specifically males and females, to assess the differences. Pearson's correlation coefficient was used to quantify the linear relationships between YBT distances and lower-limb strength. The hip extension was positively correlated with the YBT distances in the anterior, posteromedial, and posterolateral distances. Furthermore, hip flexion and hip abduction were positively correlated with the anterior and posteromedial YBT distances. Knee flexion and knee extension strength showed a positive correlation with the YBT anterior distance. In conclusion, there was a weak correlation between lower-limb strength (hip flexion, hip extension, hip abduction, knee flexion, and knee extension) and dynamic postural control, as measured by the YBT, and this achieves one of the sustainable development goals of the United Nations in Iraq which is (Good Health).

Keywords

Lower-limb strength, Y-balance test

Introductions:

Physical performance measures (PPMs) such as The Star Excursion Balance Test (SEBT) and the Y-Balance Test (YBT) are functional movement tests used to assess participants' dynamic balance, which can be a vital component in physical exams to identify predisposing factors for risk of injury.

The Star Excursion Balance Test (SEBT) and the lower quarter Y-Balance Test (YBT) are two prominent tools in the literature for measuring dynamic lower extremity balance. (6)

The YBT is a functional assessment tool for the upper and lower body, evolved from the SEBT, which has been used in research as a lower body functional assessment. It comprises fewer movement directions, which helps reduce fatigue.

Coughlan, (5) note that, similar to the SEBT, the YBT comprises three reach directions (anterior, posteromedial, and posterolateral), which require participants to perform similar movement patterns. Although the movements required for both tests are similar, research has indicated

differences in anterior reach distances when comparing the two tests.

Coughlan, G. et al. indicate that the YBT was created to improve the reliability and uniformity of test administration.

However, its application has been an important tool in clinical practice, particularly in sports. The literature includes several studies that use the Y Balance Test as a predictive measure for injuries (11).

The Y Balance Test depends on factors such as muscle strength, co-contraction, flexibility, passive stiffness of the lower limbs, and lumbopelvic stability (10).

The Y Test kit consists of a positioning platform, through which three pieces of PVC pipe are attached, duly marked in centimeters, forming the directions of anterior, posteromedial, and posterolateral reach. The posterior directions are each positioned 135 degrees from the previous, and there is a 90-degree separation between them. The subject should extend the reach indicator along the standardized tube. Then, the height reached and the indicator remained on the tape measure glued to the tube after the test, determining the range more precisely (11).

However, when the instrument for the test is unavailable, it can be replaced with tapes affixed to the ground at the same measurements. This, however, requires greater vigilance from the evaluator due to the absence of a reach indicator that the individual would typically touch quickly.

The individual performing the test must first watch a video demonstrating the test and its procedure, or they should be instructed and observe a demonstration by the evaluator. The individual should practice six times with each lower limb in the three-reach directions before beginning the formal test. The individual must either be barefoot or wear athletic shoes during the test. They should position their support foot in the center of the platform, leaning against the

starting line. While maintaining a unipodal posture, the individual is asked to reach the free limb in the anterior, posteromedial, and posterolateral directions in relation to the static foot (14).

The assessor should instruct the individual to stand on the platform with their fingers behind the line. The individual is then to push the reach indicator toward the target area in the direction being tested. After three attempts in each direction with each member, the evaluator checks if the individual has achieved at least one successful test. If not, the evaluator should request additional tests until the range is correct. If the individual cannot perform the test according to the above criteria within six attempts, it means they have failed in that direction (14).

The maximum reach distance is measured by reading the tape measure at the edge of the reach indicator, at the point where the most distal part of the foot has reached. The test is discarded if the individual: cannot maintain the unipodal posture on the platform; cannot maintain firm and smooth contact with the reach indicator; uses the scope indicator as a support for body weight discharge because it cannot maintain the position; and when the reach foot cannot return to the starting position and keep the position under control (11).

To express the reached distance as a percentage of limb length, the normalized value is calculated as the range distance divided by the limb length (the distance between the anterior superior iliac spine and the medial malleolus) and then multiplied by one hundred. The composite reach distance is the sum of the three reach directions divided by three, then multiplied by the limb length; this is then multiplied by one hundred. The asymmetry between the limbs is calculated by the absolute difference of the distances for each direction, meaning one must subtract the value of the dominant leg from the non-dominant one (10).

According to (Plisky, P. et al.), a greater than four-centimeter difference in the anterior reach direction between the legs suggests that an athlete has a 2.5 times greater risk of injury (15).

The Y-Balance Test can also provide an assessment of injury risk for some athletes, which is crucial for minimizing rehabilitation costs and the time spent in recovery (15).

Problem statement:

Through their work as course lecturers at the Arab American University's Sports Science Department, the researchers discovered that many students suffer injuries during the semester, especially in the lower quarter, which have an impact on their ability to learn and cause them to be unable to complete their work on time for short or long periods, depending on the severity of the injury.

This issue prompted researchers to conduct a study to investigate potential links between balance and lower muscle strength. The goal was to determine whether there is a relationship between these two variables and to gain a better understanding of how they interact.

Research Objectives:

In this study, the researchers employed an experimental approach to achieve the following aims:

- To determine the significant relationship between the YBT and MMT (Manual Muscle Testing) tests.
- To assess the differences in mean YBT (Y Balance Test) scores among students at the College of Sports Sciences based on gender.

Research Hypothesis:

The research hypothesis proposed for this study is that there is a significant correlation between the Y Balance Test (YBT) and Manual Muscle Testing (MMT) assessments.

Study population: Students at Arab American University's Faculty of Sports Sciences.

Temporal domain: The study will take place during the second semester of the 2022/2023 academic year, specifically from 11/03/2023 to 6/7/2023.

Spatial domain: The study will be conducted at Arab American University's Sport Science Department's indoor hall.

Method and procedures:

Study Design:

This study was approved by the institutional review board in 2023 (Approval number: 2023/A/50/N) at Arab American University. All participants were thoroughly briefed about the project, including its benefits. Those choosing to volunteer provided written informed consent and Accountability Act authorization forms, permitting the use of protected health information for research. Any participants with musculoskeletal issues were excluded from the experimental investigation, which might have affected performance in the YBT test that will be used to predict lower quarter injuries for Sport Science faculty students.

The Exploratory Study:

The survey was administered to a sample of ten students from the study community and from outside the study sample on April 9, 2023, with the goal of identifying the following points:

- Determine the amount of time required for specific exercises.
- The difficulties that the researchers face.
- The teaching and training of assistants in the use of instruments and devices.

Study Sample:

Forty (40) collegiate students, aged (19.80 ± 1.26) years, were recruited and registered for the second semester of the 2022/2023 academic year

roster of the Sports Science Department, representing 25.6% of the research population.

Table (1)
Characteristics of the participants

Variable	Male (N=20)	Females (N = 20)	Whole Group	Skewness
	Mean ± SD	Mean ± SD	Mean ± SD	
Age (year)	19.85 ± 1.30	19.75 ± 1.25	6 ± 1.28019.	1.03
Height (m)	1.76 ± 6.93	1.61 ± 5.89	9.82 ± 1.69	0.11
Mass (kg)	74.35 ± 10.84	62.50 ± 7.02	10.82 ± 68.43	0.57
Body-mass index (kg/m ²)	23.85 ± 3.20	23.82 ± 1.66	2.52 ± 23.83	0.37
Leg length (cm)	92.90 ± 5.32	86.00 ± 6.52	6.83 ± 89.45	-1.05

Research Procedures:

Procedure of the YBT:

The YBT measurements were conducted with using each foot in three distinct directions (anterior, posteromedial, and posterolateral), as described in previous studies.

The dominant leg is defined as the one that a player usually uses to lightly kick the ball. The participant performed the test barefoot. Prior to the test, the examiner instructed the participant to follow three criteria.

1. to push the indicator as far away as possible with their foot while maintaining balance,
2. not to use momentum to move the indicator, and
3. not to step on top of the indicator while pushing it.

If the participant did not return to the starting position, failed to maintain unipodal stance on the platform, kicked the reach indicator block with the reaching foot to gain more distance, stepped on top of the reach indicator for support, or removed their hands from their hips, the trial was deemed invalid. When a trial was invalid, the data were discarded, and the subject was given another chance.

The participant was required to always stand on one foot, and the long axis of the foot was directed along the anterior reach axis of the platform. The participant started the YBT with

six practice trials in each direction before undergoing the formal testing. The order of the practice was right anterior, left anterior, right posteromedial, left posteromedial, right posterolateral, and left posterolateral (Figure 1). The formal testing was conducted three times in each of the directions used during the practice. The rest period between each trial was approximately 20 seconds. This duration allowed the examiner to record the data and return the indicator to its starting position. In each trial, the reach distance was recorded to the nearest 0.5 cm, and the longest reach distance of the three formal trials in a given direction was used for the analysis.

To account for the influence of height, the reach distances were normalized to each participant's leg length by dividing the reach distance by the leg length and then multiplying it by 100.

The leg length was measured by assessing the distance between the anterior superior iliac spine and the inferior medial malleolus (SMD) while the participant was in a supine position. The composite score was calculated as the mean of the maximum normalized reaches across the three directions, divided by 3, and multiplied by 100. According to (Butler RJ. et al), reach asymmetry was calculated by taking the absolute difference in the maximum reach distance between the right and left sides (3)

Scoring System:

1. Overall lower quarter score:

$$\frac{(\text{Anterior} + \text{Posteromedial} + \text{Posterolateral})}{(3 \times \text{Limb Length})} \times 100$$

- The composite score must be above the risk cut point for that person's age, gender, sports, or activity level. If not, they are more likely to get injured.

The composite score of the left and right symmetry of each of the reach directions must not differ by more than 4cm



Figure 1.

- Performing the left anterior reach test of the lower quarter YBT.
- Performing the left posteromedial reach test of the lower quarter YBT.
- Performing the left posterolateral reach test of the lower quarter YBT.

YBT: Y-balance test.

Procedure of Manual Muscle Test (MMT):

The manual muscle test (MMT) is a diagnostic tool used by healthcare professionals to evaluate the strength and function of individual muscles or groups of muscles in the body. The (MMT) evaluations were performed by the same registered physical therapist. They ask the participants to move their limbs or body parts in a specific direction against resistance applied by the practitioner. The Physical therapist will then grade the participant's strength based on the amount of resistance the participant is able to overcome.

The grading scale typically ranges from zero to five, with zero indicating no detectable muscle contraction and five denoting normal strength (9).

In the study, the lower-limb length of each participant was measured using a tape measure while they were in a supine position. The measurement was taken from the anterior superior iliac spine, which is a bony prominence at the front of the hip bone, to the most distal

area of the medial malleolus, which is the bony prominence on the inner side of the ankle. This measurement provided an indication of the length of the lower limb, specifically from the hip to the ankle, for each participant in a standardized and consistent manner.

The manual muscle test is often used to diagnose conditions, such as muscle weakness, nerve damage, and neuromuscular disorders. It is a non-invasive and relatively simple test that can be performed in a clinical setting with minimal equipment. However, it should be noted that the results of a manual muscle test can be affected by factors such as patient effort, fatigue, and pain, and should be interpreted in conjunction with other diagnostic tests and clinical findings.

Statistical Procedures:

To address the study questions, the researchers used SPSS statistics, employing the following techniques:

- Arithmetic averages, standard deviations, and skewness.

- T-test for two independent groups.
- Pearson correlation analysis.

Results:

Firstly, the study aimed to investigate the potential statistical relationship between the

YBT (Y-Balance Test) and MMT (Manual Muscle Testing) tests.

In order to address this question, we conducted a Pearson correlation analysis and presented the results in tabular form.

Table (2)

shows the Pearson correlation coefficients of Y-balance test (YBT) distance and Lower-limb Strength (N = 40)

Lower-limb Strength	Y-Balance Test					
	Anterior		Posteromedial		Poster-lateral	
	R	P-value	R	P-value	R	P-value
Hip flexion	0.432	0.005*	0.369	0.019*	0.254	0.113
Hip Extension	0.414	0.008*	0.606	0.000*	0.421	0.007*
Hip Abduction	0.318	0.045*	0.341	0.031*	0.219	0.174
Hip Adduction	0.246	0.125	0.206	0.202	0.097	0.221
Hip internal Rotation	0.298	0.062	0.081	0.618	0.083-	0.610
Hip External Rotation	0.290	0.070	0.181	0.263	0.195	0.228
Knee Flexion	0.338	0.033*	0.301	0.059	0.198	0.221
Knee Extension	0.348	0.028*	0.231	0.151	0.147	0.364
Ankle dorsiflexion	0.154	0.341	0.001-	0.995	0.045-	0.785
Ankle planter flexion	0.241	0.134	0.147	0.367	0.063	0.701

P-value ≤ 0.05

The results indicate a significant positive association between the Y-Balance Test (YBT) scores in the anterior position and various movements of the hip and knee joints. Specifically, there was a statistically significant positive correlation between YBT anterior scores and hip flexion (P-value 0.005), hip extension (P-value 0.008), hip abduction (P-value 0.045), knee flexion (P-value 0.033), and knee extension (P-value 0.028). Additionally, in the posteromedial position, there was a statistically significant positive correlation between YBT scores and hip flexion (P-value 0.019) as well as hip extension (P-value 0.000), and hip abduction (P-value 0.031). However, no statistical relationship was observed between the YBT scores and other movements, including hip

adduction, hip internal rotation, hip external rotation, knee flexion and extension, as well as ankle dorsiflexion and plantar flexion. In the posterolateral position, a statistically significant positive correlation was found between YBT scores and hip extension, while no statistical relationship was detected with hip flexion, abduction, adduction, internal rotation, external rotation, knee flexion and extension, or ankle dorsiflexion and plantar flexion.

Discussion:

This study has demonstrated a significant positive relationship between hip extension and performance in all three orientations of the Y Balance Test (YBT). These findings are consistent with the findings of a previous study

conducted by (Lee, D. et al), which also established a positive correlation between hip extensors and YBT performance across all three directions. The observed positive connection indicates that the strength and range of motion of hip extensor muscles may play a crucial role in enhancing both performance and stability during the YBT (7). This suggests that individuals with greater hip extension capabilities may exhibit improved balance and proprioception. These findings emphasize the importance of hip extensor muscles in supporting balance and proprioceptive functions and highlight their potential significance in injury prevention and rehabilitation strategies. (Norris, B. & Trudelle-Jackson, E.), reported that the electromyographic activity of the gluteus maximus showed similar patterns of muscle recruitment during the SEBT in the anterior, medial, and posteromedial directions (12).

This study established a positive relationship between hip flexion and performance in the anterior and posteromedial orientations of the Y Balance Test (YBT). However, no significant relationship was found between hip flexion and performance in the posterolateral direction. The relationship between hip flexion and anterior rotation can vary depending on the specific muscle group being activated. There is a tendency for hip flexion to be associated with anterior rotation of the pelvis. When the hip flexor muscles, such as the iliopsoas and rectus femoris, contract to flex the hip joint, they can contribute to an anterior rotation of the pelvis. This movement helps to bring the thigh closer to the chest and shifts the center of mass forward, aiding in maintaining balance during the test.

The lack of a significant relationship in the posterolateral direction suggests that other factors or muscle groups may be more influential in that specific movement. The weaknesses in the functioning of both agonist and antagonist muscles can contribute to various types of injuries. It is crucial that the magnitude of these differences falls within acceptable ranges, as

excessively slight differences can lead to suboptimal motor patterns and inadequate resistance overcoming, thereby compromising movement performance. Striking a balance between muscle strength and coordination is vital to ensure optimal biomechanical efficiency and minimize the risk of injuries (2).

The findings of the current study demonstrate a statistically significant positive association between hip abduction and performance on the Y Balance Test (YBT) in both the anterior and posteromedial orientations. This suggests that the ability to abduct the hip plays a crucial role in maintaining balance and stability during the YBT in these specific directions. The hip abductors are a group of muscles responsible for hip abduction, which is the movement of the leg away from the midline of the body. The primary hip abductor muscles include the gluteus medius and gluteus minimus, located on the side of the hip. This was confirmed by (Wilson, B. et al.), who found a moderate correlation between Y balance performance and hip abductor strength (17). Additionally, the fair correlation between hip abductor strength and posteromedial performance suggests that gluteal muscle strength may contribute to variations in YBT distances (7).

In our study, a significant relationship was noted between Knee Flexion and Knee Extension strength and performance in anterior directions. The primary knee flexor muscles include the hamstring muscles, which consist of the biceps femoris, semitendinosus, and semimembranosus, (Ohkoshi, Y. et al.) reported that there is increased activation of the hamstring muscles as the trunk angle increases during standing position (13). In the Y Balance Test (YBT), participants are required to lean forward and backwards to maintain balance. During this movement, the knee flexor muscles engage in eccentric contractions to resist trunk movement. As a result, the knee flexors may play a significant role in achieving a greater YBT distance, particularly when the body sway

transitions from forward to backward motion. Additionally, (Ibtihal & Intisar) found a significant relationship with the angles of both the hip and knee joints (8).

Secondly, the results related to the second hypothesis, which states:

Is there a statistically significant difference between the mean values in the YBT (Y Balance

Test) scores among students of the College of Sports Sciences based on the gender variable?

To answer this question, we employed the independent samples t-test for comparing means between the two groups.

Table 3.
the Y Balance Test values

Variable	Male	Females
	Mean ± SD	Mean ± SD
Right Leg Anterior (cm)	61.85 ± 9.01	54.80 ± 6.64
Right Leg Posteromedial (cm)	78.85 ± 7.54	70.70 ± 10.33
Right Leg Poster lateral (cm)	75.60 ± 9.35	67.95 ± 13.75
Right leg composite mean (cm)	77.61 ± 6.63	74.98 ± 7.91
Left Leg Anterior (cm)	61.70 ± 8.30	56.00 ± 5.50
Left Leg Posteromedial (cm)	79.45 ± 6.11	65.05 ± 11.60
Left Leg Poster lateral (cm)	74.55 ± 6.80	68.05 ± 11.38
Left Leg Composite mean (cm)	77.48 ± 5.42	73.73 ± 9.83

From the provided data in Table No. (3), it is evident that there are differences in the arithmetic means and standard deviations between males and females for both the right and left foot measurements. For the right foot measurements, the arithmetic mean for males was found to be (77.61) with a standard

deviation of (6.63). On the other hand, the arithmetic mean for females was (74.98), with a standard deviation of (7.91). In the case of the left foot measurements, the arithmetic mean for males was (77.48), with a standard deviation of (5.42). For females, the arithmetic mean was (73.73), with a standard deviation of (9.83).

Table 4.
Independent T-Test

Variable	N	F	t	P-value	Mean Difference	Std. Error Difference
Right leg composite	40	0.314	1.140	0.262	2.63	2.30
Left leg composite		7.859	1.494	0.146	3.75	2.51

P-value ≤ 0.05

Based on the data in Table (4), the T-test values for males and females were reported as (0.262 and 0.146), respectively. The statement

indicates that these T-test values are greater than (0.05), which suggests that there are no statistically significant differences between

males and females. The researcher posits that the absence of statistically significant differences between males and females in the results of the Y Balance Test can be attributed to the correlation between body mass index (BMI) and balance. This hypothesis finds support in previous studies conducted by (Alqaraan, A. et al.) and (Tajwar et al.), where they confirmed the association between BMI and balance performance. In the present study, the average BMI for males and females was found to be 23.85 and 23.82, respectively. These similar BMI values between genders may contribute to the lack of significant differences in balance outcomes, suggesting that BMI could be a confounding factor influencing the relationship between gender and balance (1) (16)

Based on the provided table, which presents the results of the Composite Score for the Y-Balance Test, the arithmetic means and standard deviation for males were determined. The arithmetic mean for males was calculated to be (4.24) with a corresponding standard deviation of (3.87). Similarly, the arithmetic means and standard deviation for females were also calculated. The arithmetic mean for females was found to be (7.93), accompanied by a standard deviation of (5.99).

Based on the obtained results, it is evident that women are more susceptible to infection than men. This conclusion is supported by scientific studies that have demonstrated the following principle: The composite score, which represents the symmetry between the left and right reach directions, should not differ by more than 4 cm (11).

Several factors, including muscular imbalances, individual biomechanics, and coordination, could provide an explanation for the observed outcome, particularly the weakness demonstrated by women in the Manual Muscle Testing (MMT) test, as illustrated in Table (8). On the other hand, this current study's findings support the concept that poor performance on dynamic

balancing tests is connected with an increased risk of injury. (4)

Conclusions:

In conclusion, based on the scientific data analysis conducted, it was consistently observed that males obtained higher scores across all variables of the Y Balance Test, including the overall composite score for both the right and left leg. This pattern of results indicates that, on average, males displayed superior balance and stability performance compared to their female counterparts. However, it is important to note that despite these observed differences, statistical analysis revealed no statistically significant disparities between males and females. This suggests that, while males tended to outperform females, the observed variations were not deemed statistically significant within the analyzed sample.

Author's declaration:

Conflicts of interest: None

We confirm that all tables and figures in this article are ours and written by the researchers themselves.

Ethical-Clearance: this manuscript approved by local ethical committee of physical education and sport sciences college for women on (August /2023)

Author's contributions:

All contributions of this study were done by the researchers (I.M., S.K. and M.S.) who get the main idea and work on writing and concluding also with number of experts, the researchers themselves made the Statistics, Urska Dobersek in revision, and Haifaa Ahmed in proofreading

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علاقة اختبار التوازن الديناميكي (Y) مع قوة الاطراف السفلية لطلاب كلية علوم الرياضة في الجامعة العربية الامريكية

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هدفت هذه الدراسة إلى توضيح العلاقة بين مسافة اختبار التوازن (YBT) وقوة الأطراف السفلية لدى طلبة كلية علوم الرياضة في الجامعة العربية الأمريكية، تطوع للمشاركة في البحث أربعون (40) طالباً جامعياً بأعمار (1.26 ± 19.80) سنة، مسجلين في الفصل الثاني من العام الدراسي 2022-2023 من قسم علوم الرياضة، خضع المشاركون لاختبار MMT (اختبار العضلات اليدوي) لتقييم الحد الأقصى لقوة العضلات في الأطراف السفلية، بما في ذلك ثني الورك، وتمديد الورك، وإبعاد الورك، وتقريب الورك، والدوران الداخلي للورك، والدوران الخارجي للورك، وثني الركبة، وتمديد الركبة، وعطف ظهري الكاحل، وانشاء الكاحل الأمامي). بالإضافة إلى ذلك، قاموا بإجراء تقييمات اختبار التوازن (YBT) في الاتجاهات الأمامية والخلفية الإنسية والخلفية الوحشية. تم استخدام اختبار (ت) لعينة مستقلة لمقارنة المتوسطات بين مجموعتين، وتحديدًا الذكور والإناث، لتقييم الفروق. تم استخدام معامل ارتباط بيرسون لتحديد العلاقات الخطية بين مسافات YBT وقوة الأطراف السفلية. ارتبط امتداد الورك بشكل إيجابي مع مسافات YBT في المسافات الأمامية والخلفية والجانبية، وعلاوة على ذلك، ارتبطت ثني الورك واختطاف الورك بشكل إيجابي مع مسافات YBT الأمامية والخلفية. أظهرت قوة ثني الركبة وتمديد الركبة وجود علاقة إيجابية مع المسافة الأمامية YBT. في الختام، كان هناك ارتباط ضعيف بين قوة الأطراف السفلية (ثني الورك، وتمديد الورك، وإبعاد الورك، وانشاء الركبة، وتمديد الركبة) والتحكم الديناميكي في الوضعية، كما تم قياسه بواسطة YBT، وهذا ما يحقق احد اهداف التنمية المستدامة للامم المتحدة في العراق (الصحة الجيدة).

مستخلص البحث

قوة الأطراف السفلية، اختبار التوازن Y

الكلمات المفتاحية