

Motor Postural Control Ability and Sports Injury Risk Assessment of Traditional Chinese Opera Performers

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Abstract: The ability to control movement and posture significantly affects the quality of traditional Chinese opera performers' performances. However, because the traditional training model for traditional Chinese opera performance lacks instruction in human biology, medicine, kinesiology, biomechanics, exercise physiology, and anatomy, there is a lack of quantifiable assessment methods in the field for evaluating motor postural control ability and sports injury risk. This study was the first to use the Y-Balance standardized screening tool to test college students majoring in traditional Chinese opera performance. The results were as follows: (1) the composite scores for dynamic balance control ability of the left and right lower limbs were both 0.97, indicating relatively good bilateral symmetry, but the overall score was lower than that of female college students majoring in dance performance; (2) more than one third of the traditional Chinese opera performance majors had unilateral or bilateral CS values below 0.95, and one quarter had TLA values ≥ 0.05 ; (3) the number and proportion of male traditional Chinese opera performance majors with CS values below 0.95 and TLA values ≥ 0.05 were both higher than those of female students. The conclusion is that the motor postural control ability of college students majoring in traditional Chinese opera performance is weaker than that of college students majoring in dance performance, and that male traditional Chinese opera performance majors are deficient compared with female students in dynamic balance, neuromuscular control, and weak-side functional training. In the future, training in neuromuscular control ability and proprioception should be strengthened.

Keywords: Traditional Chinese Opera Performance; Movement and Posture Control; Risk of Sports Injury; Y-Balance

1. Introduction

Singing, recitation, acting, and acrobatic fighting are the four artistic means of traditional Chinese opera performance and the four basic skills that performers must master, collectively known as the "Four Skills" (si gong) [1,2]. Among these four basic skills, acting and acrobatic fighting both use the body as their medium, that is, they express specific artistic effects by completing a variety of bodily movements [3]. Therefore, physical training (also called body training or physical conditioning) has become an important stage that every traditional Chinese opera performer must undergo in their performing career. In the process of physical training for traditional Chinese opera performers, the ability to control movement and posture greatly affects the quality of physical performance. Dynamic balance ability is a direct reflection of dynamic postural control ability and is an important physiological function of the human body [4]. For traditional Chinese opera performers, in order to achieve specific performance effects, they are often required to complete highly difficult movements such as rotations, flips, and jumps followed by flips while the body is under conditions of unstable support. At this time, if dynamic balance ability is weak, it will reduce the function of bodily movement, affecting not only the performance of movement techniques in physical performance but also increasing the risk of sports injuries during physical performance. Therefore, it is necessary to scientifically assess the motor postural control ability of traditional Chinese opera performers and to predict possible sports injury risks based on the assessment results. Due to the lack of courses in natural sciences such as human biology, medicine,

kinesiology, biomechanics, exercise physiology, and anatomy in the traditional training model for traditional Chinese opera performance, assessments of motor postural control ability and sports injury risk in the field were previously mainly based on personal experience and lacked quantifiable assessment methods [5-7]. The Y-Balance Test (YBT) is a standardized screening tool used to assess dynamic balance and functional symmetry. It can comprehensively evaluate strength, flexibility, neuromuscular control, core stability, range of motion, balance, and proprioception under an unstable state of unilateral support [8], and can also serve as a tool for assessing injury risk [9]. Therefore, this study is the first to conduct the YBT among traditional Chinese opera performers to assess their motor postural control ability and the risk of sports injuries caused by weak dynamic balance ability.

2. Methods

2.1 Participants

The participants of this study consisted of 80 university students majoring in traditional Chinese opera performance at the China National Academy of Traditional Chinese Opera, including 41 males and 39 females. Their basic demographic characteristics are presented in Table 1. All participants were in good health and had no history of sports injuries within the past year.

Table 1. Basic Information of Study Subjects

	All(n=80)	Males(n=41)	Females(n=39)
Age (years)	20.60±1.78	21.15±1.79	19.83±1.44
Height (m)	1.71±0.08	1.76±0.05	1.64±0.05
Body weight(kg)	63.34±12.99	70.00±12	53.59±6.18
BMI	20.59±3.32	21.20±3.60	19.97±1.99
Professional training duration(years)	7.72±2.14	7.76±1.91	7.68±2.03

2.2 Methods

In this study, the Body Balance Standard Test Kit was used to assess lower-quarter dynamic balance capacity in all participants (Lower Quarter Y-Balance Test, YBT-LQ). First, the lower limb length of the participants was measured. Participants were asked to remove their shoes and socks and lie supine on a mat, with both legs naturally extended, toes pointing upward, and feet separated at approximately shoulder width. A soft tape measure was used to measure the distance from the anterior superior iliac spine to the inferior edge of the medial malleolus. Then, the maximum reach distance of the contralateral

lower limb in three directions—anterior, posterolateral, and posteromedial—was measured while the participant supported themselves on one lower limb. Each directional movement was repeated three times, and the maximum value was recorded. Finally, SPSS 22.0 software was used to collate and statistically analyze all the test data, and independent-samples t-tests were used to examine between-group differences, with the significance level set at $P < 0.05$.

3. Results

3.1 YBT Composite Score (CS) of both Lower Limbs for University Students Majoring in Traditional Chinese Opera Performance

The YBT results for university students majoring in traditional Chinese opera performance in this study are presented in Table 2. The results indicate that the overall composite score for the left lower limb of the entire cohort was 0.97 ± 0.14 , with scores of 0.97 ± 0.08 and 0.97 ± 0.19 for males and females, respectively. The overall composite score for the right lower limb was 0.97 ± 0.13 , with scores of 0.97 ± 0.07 and 0.97 ± 0.20 for males and females, respectively. The composite scores of the male and female participants were very similar, and no statistically significant differences were observed between the groups.

Additionally, statistical analysis was performed for cases where the YBT composite score (CS) of both lower extremities was below 0.95. As shown in Table 3, among all participants, 28 individuals (34.57%) had a CS < 0.95 , including 20 males (48.78%) and 8 females (20.51%).

3.2 Maximum Extension Distance of both Lower Limbs in Three Directions for University Students Majoring in Traditional Chinese Opera Performance

According to Table 2, the sum of the maximum reach distances across all three directions for the entire sample of participants was 277.06 ± 38.76 cm. When the left leg was bearing weight, the maximum extension distances of the right leg in the anterior, posterolateral, and posteromedial directions were 66 ± 7.5 cm, 104 ± 8.79 cm, and 110.8 ± 8.52 cm, respectively. When the right leg was bearing weight, the maximum extension distances of the left leg in the same three directions were 67 ± 8.2 cm, 105 ± 8.6 cm, and 108.5 ± 7.91 cm, respectively. Further comparison

between males and females revealed that, whether supporting on the left or right leg, the sum of the maximum reach distances achieved by males in all three directions was significantly

greater than that of females (Reach (left): 286.78 ± 20.55 cm vs. 263.31 ± 52.02 cm, $P < 0.05$; Reach (right): 285.12 ± 19.16 cm vs. 263 ± 52.10 cm, $P < 0.05$).

Table 2. YBT Test Results (Mean $\pm$ Standard Deviation)

group	Reach (left)(cm)	A (left) (cm)	PM (left) (cm)	PL (left) (cm)	Reach (right) (cm)	A (right) (cm)	PM (right) (cm)	PL (right) (cm)	CS(left)	CS (right)
All(n=80)	277.06 ± 38.76	66 ± 7.5	104 ± 8.79	110.8 ± 8.52	275.96 ± 38.19	67 ± 8.2	105 ± 8.6	108.5 ± 7.91	0.97 ± 0.14	0.97 ± 0.13
Male(n=41)	286.78 ± 20.55	67 ± 8.2	106 ± 8.4	113.6 ± 8.01	285.12 ± 19.16	67 ± 8.7	106 ± 8.6	111.9 ± 7.43	0.97 ± 0.08	0.97 ± 0.07
Female(n=39)	$263.31 \pm 52.02^*$	$65 \pm 6.00^*$	$101 \pm 8.5^*$	$106.6 \pm 7.47^*$	$263 \pm 52.10^*$	$66 \pm 7.6^*$	$102 \pm 8^*$	$103.6 \pm 5.71^*$	0.97 ± 0.19	0.97 ± 0.20

Note: A denotes the reach distance when extending forward; PM denotes the reach distance when extending posteriorly and medially; PL denotes the reach distance when extending posteriorly and laterally; Reach = A + PM + PL; CS denotes the composite score for a single lower limb, calculated as $CS = \text{Reach} / (bl \times 3)$, where bl represents the length of the lower limb; * indicates a comparison between males and females, with $P < 0.05$.

Table 3. Statistical Results of the Proportion of Cases with a Composite Score (CS) Below 95%

group	All (n=80)	Male (n=41)	Female (n=39)
Number of participants with CS < 0.95 (n)	28	20	8
Proportion of CS < 0.95	34.57%	48.78%	20.51%

3.3 Differences in Balance Ability of the Bilateral Lower Limbs in College Students Majoring in Traditional Chinese Opera Performance (TLA)

Based on the results of the reach distances in three directions using the YBT, the difference in lower limb balance capacity between the two sides (TLA) can be calculated using the following formula: $TLA = |\text{Reach L} - \text{Reach R}| / ((\text{Reach L} - \text{Reach R}) / 2)$. The results of the calculation of differences in bilateral lower-limb balance ability among university students majoring in traditional Chinese opera performance in this study are presented in Table 4. As shown in Table 4, the TLA value of all participants in this study was 0.03 ± 0.02 . A total of 20 participants had a TLA value ≥ 0.05 , accounting for 25.00%, among whom 15 were male (36.59%) and 5 were female (12.82%), with the number of males exceeding that of females.

Table 4. Statistical Results of Balance Differences between the Lower Limbs (TLA)

group	All(n=80)	Male(n=41)	Female(n=39)
value of TLA	0.03 ± 0.02	0.04 ± 0.03	0.03 ± 0.02
Number of subjects with TLA ≥ 0.05	20	15	5
Percentage of cases with TLA ≥ 0.05 (%)	25.00%	36.59%	12.82%

4. Discussion

4.1 Comprehensive Performance of Dynamic Postural Control in Undergraduate Students Majoring in Traditional Chinese Opera Performance

The YBT composite score (CS) of both lower limbs can be used to assess lower limb dynamic postural control ability. Also, the YBT composite score (CS) reflects the body's ability to maintain stable postural control during unilateral support movements. A higher CS value indicates superior dynamic control capability [10]. In this study, the YBT test results for all university students majoring in traditional Chinese opera performance were as follows: the composite score for the left lower limb was 0.97 ± 0.14 , and the composite score for the right lower limb was 0.97 ± 0.13 . Wen Ru et al. conducted the same YBT study on female university students majoring in dance performance, and the composite scores of the left and right lower limbs were 1.02 ± 0.07 and 1.01 ± 0.06 , respectively [4]. Comparative analysis reveals that, although both traditional Chinese opera and dance performances require performers to possess the ability to dynamically control their body posture on stage, the stable control ability of male university students majoring in traditional Chinese opera is significantly lower than that of female university students majoring in dance. This same result persists even when comparing female students only. The ability of the human body to regulate dynamic postural stability is associated with well-developed proprioception, neuromuscular control, and lower-limb muscle strength. The comparative findings between traditional Chinese opera performers and dance performers suggest that, during physical training, the former may require relatively less emphasis on dynamic postural control exercises—such as bilateral symmetry training, balance training, and proprioceptive training—compared to the latter. This study also conducted statistical analyses of the CS scores for male and female participants.

Although the maximum reach in all three directions—measured from the left and right supports—was significantly greater in males than in females ($P < 0.05$), which may be attributed to the significantly greater height of males, no statistically significant difference was observed between males and females in the final CS score. This is because the CS score is a relative value, which eliminates the influence of differences in lower limb length.

4.2 Evaluation and Analysis of the Single-Leg Composite Score (CS) < 0.95 in both Lower Extremities

The BYT Composite Score (CS) reflects differences in the strength or balance capacity of both lower limbs during support, while also indicating the risk of injury associated with a decline in dynamic postural control ability. It is commonly believed that a CS value below 0.95 indicates an increased risk of injury. As shown in Table 3, among the 80 university students majoring in traditional Chinese opera performance in this study, 28 individuals exhibited CS values below 0.95 in either or both lower extremities, accounting for approximately 34.57% of the total sample. This indicates that these individuals face an increased risk of sports injuries due to limited capacity to control dynamic adjustments of body posture stability. In similar studies, the proportion of female university students majoring in dance performance with a CS value below 0.95 was approximately 17.07% [4]. Compared with the CS value assessment results of traditional Chinese opera performers in this study, the latter group faces a higher risk of sports injuries due to their limited ability to control dynamic adjustments of body posture stability.

Furthermore, a comparison was conducted between male and female participants in this study regarding the proportion of individuals whose CS score was below 0.95. The results showed that the number of males with a CS score below 0.95 (20 individuals, accounting for approximately 48.78%) was significantly higher than that of females (8 individuals, accounting for approximately 20.51%). This further indicates that males face a higher risk of sports injuries due to weaker control over dynamic adjustment of body posture stability compared to females.

4.3 Assessment Results of Bilateral Lower Limb Balance Difference (TLA)

Based on the test results of the reach distances in three directions using the YBT, the difference in lower limb balance capacity between the two sides (TLA) can be calculated using the following formula: $TLA = |\text{Reach L} - \text{Reach R}| / ((\text{Reach L} + \text{Reach R}) / 2)$. The results of the calculation of differences in bilateral lower-limb balance ability among university students majoring in traditional Chinese opera performance in this study are presented in Table 4. It is generally believed that the greater the functional balance between the two sides of the body, and the smaller the TLA value, the lower the risk of injury. Conversely, the greater the imbalance, the higher the risk of injury. Furthermore, when $TLA \geq 0.05$, it indicates poor symmetry in muscle strength and motor control between the lower limbs, posing a risk of injury.

As shown in Table 4, the TLA values for all participants in this study were 0.03 ± 0.02 , which is close to that of university students majoring in dance (0.03 ± 0.04). This indicates that, in terms of mean values, the overall difference in bilateral balance ability among university students majoring in traditional Chinese opera performance is generally acceptable. However, among the 20 participants in this study whose TLA values were ≥ 0.05 , the proportion (25.00%) was higher than that among female university students majoring in dance (14.63%) [4], indicating that the disparity in lower-limb balance capacity between the two lower limbs was more pronounced in the former group than in the latter. Furthermore, the finding that the number of male students with $TLA \geq 0.05$ (15 individuals) was higher than that of female students (5 individuals) in this study indicates that the disparity in lower-limb balance ability between the lower limbs of male and female university students majoring in traditional Chinese opera performance is more pronounced in males than in females. Overall, college students majoring in traditional Chinese opera performance exhibit relatively balanced bilateral balance capabilities. However, some individuals still display significant disparities in bilateral balance, posing a potential risk of sports-related injuries—a phenomenon that is particularly pronounced among male students.

4.4 Comparison of Postural Control Ability and Risk of Sports Injuries between Male and Female Undergraduate Students in Traditional Chinese Opera Performance

Regarding gender differences, in the YBT test,

the proportion of male university students majoring in traditional Chinese opera performance who had a CS value <0.95 and a TLA ≥ 0.05 was higher than that of female university students. This indicates that the former group possesses slightly weaker ability to control their body posture compared to female students, and consequently, they face a slightly higher risk of sports-related injuries. In traditional Chinese opera performances or daily physical training, male performers must execute exercises that are generally more challenging and involve greater exercise intensity compared to female performers—such as high-difficulty techniques like flips and leaps. These movements place higher demands on their lower-limb strength and their ability to maintain body control upon landing. Consequently, if they lack adequate control over their body posture or exhibit asymmetry between their limbs, they are more susceptible to sports injuries. Although males generally possess relatively greater strength than females, they still exhibit weaker postural control compared to females. This indicates deficiencies in neuromuscular control and proprioceptive training, which in turn limits the development of their dynamic balance capabilities. Therefore, in future training sessions, physical training programs tailored to male participants should be further refined and optimized.

5. Conclusions and Recommendations

5.1 Conclusion

Based on the YBT results, the composite scores for dynamic balance control ability of the left and right lower limbs among university students majoring in traditional Chinese opera performance were both 0.97, indicating good symmetry between the two sides. However, these scores were overall lower than those of female university students majoring in dance performance. This indicates that students majoring in traditional Chinese opera performance should enhance their ability to control dynamic postures during physical training, and may draw lessons from their experience in dance training.

According to the lower limb YBT composite score (CS) obtained from the tests, more than one-third of university students majoring in traditional Chinese opera performance exhibited a unilateral or bilateral CS value below 0.95. Furthermore, based on the calculated TLA values, one-quarter

of these students had a TLA value ≥ 0.05 . The above two findings suggest that this population may be at risk of sustaining sports injuries due to insufficient capacity for dynamic balance regulation or functional asymmetry between the two sides.

Regarding gender differences, among students majoring in traditional Chinese opera performance, the number and proportion of male students with a CS value below 0.95 and a TLA value ≥ 0.05 were both higher than those of female students. Given that male students generally possess greater muscle strength than female students, it is concluded that their physical training may lack sufficient focus on dynamic balance, neuromuscular control, and functional training for the weaker side. Therefore, greater attention should be paid to these areas in the future.

5.2 Recommendations

It is recommended to conduct regular YBT tests for traditional opera performers, establish individual records, and prioritize follow-up monitoring for those with a CS value <0.95 or a TLA ≥ 0.05 .

It is recommended to optimize the physical training regimen for male traditional opera performers by incorporating exercises targeting the hip abductors, hip extensors, knee flexors, ankle joint stability, and core stability of the lower limbs. Furthermore, balance and proprioception training should be integrated into the training of "tanzi gong," "bazi gong," and posture training.

It is recommended to integrate the YBT test with FMS, isokinetic muscle strength testing, proprioception assessment, and three-dimensional motion analysis, among other methods, to enhance the accuracy and comprehensiveness of injury risk prediction.

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