Hamstring Flexibility in Wushu Athletes

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Preferred Running Head: Hamstring Flexibility in Wushu

Abstract Word Count: 222

Manuscript Word Count: 2390

Number of Tables and Figures: 1 table & 1 Figures

Conflict of Interest: There are no conflicts of interest concerning this paper.

Abstract

In this preprint we show a study that aimed to evaluate hamstring flexibility in young athletes practicing modern Taolu Wushu using the Sit and Reach test. Sixteen athletes who were members of the national team and 16 who were not part of the national team participated in this cross-sectional study. Descriptive statistics showed that the national team members had significantly higher flexibility levels than the non-members ($p < 0.01$, Cohen's $d = 1.97$). Logistic regression analysis revealed that the Sit and Reach test was a significant predictor of national team membership, with a pseudo-R2 of 0.52. These findings suggest that hamstring flexibility is an important factor for the selection of athletes to the national team in Wushu. Comparing our results to other studies in athletes, our findings are consistent with previous research showing that athletes who are part of national teams tend to have greater flexibility levels than those who are not selected. This study highlights the importance of hamstring flexibility in the selection process for national teams in modern Taolu Wushu. The Sit and Reach test is a simple and effective tool for evaluating hamstring flexibility in young athletes, and it may be used to identify potential national team members. Coaches may use this information to design training programs that focus on improving flexibility levels, which may lead to better athletic performance and success in competition.

Introduction

Modern Wushu is a sport based on traditional Chinese martial arts, which has gained international recognition and has been included in various national and international competitions . One of the disciplines of Modern Wushu is Taolu, a series of choreographed movement routines that involve defensive and offensive techniques against imaginary opponents while maintaining certain technical, performance, and difficulty requirements (Montalvo et al., 2020, 2022; Tan et al., 2017). Athletes competing in Modern Wushu require various skills to meet the specific requirements of the sport, such as lower limb power, coordination between body segments, and demanding full-body flexibility (Benouaich et al., 2015; Cheah et al., 2016; Tan et al., 2016).

Hamstring flexibility is a critical aspect for achieving peak performance in wushu athletes, primarily due to the demands of performing aerial kicks, which require maximum hip flexion and full knee extension in the kicking leg . Despite the importance of this physical attribute in wushu athletes, there is limited information on the importance of hamstring assessment with Wushu athletes, furthermore, South American wushu athletes, and no study has been conducted on Chilean junior wushu athletes (Artioli et al., 2009).

Considering the aforementioned context, it is imperative to systematically investigate hamstring flexibility in Wushu athletes by conducting a comparative analysis between individuals who are members of a national team and those who are not. This research endeavors to augment the current body of knowledge regarding flexibility in Wushu athletes, while providing valuable insights into the requisite physical conditioning for achieving optimal performance in this discipline. The findings will ultimately enable coaches and practitioners to devise evidence-based, targeted training programs for athletes.

Our specific objective is to examine potential disparities in hamstring flexibility between Chilean Wushu athletes who are members of the National Team and those who are not. If a significant difference is identified, we intend to evaluate the predictive capacity of hamstring flexibility in determining team placement. Our hypothesis posits that junior athletes affiliated with the National Team demonstrate superior flexibility compared to non-member counterparts, with hamstring flexibility serving as a discriminative variable between the two cohorts.

Methods

This study employed a quantitative, descriptive, cross-sectional, and non-experimental research design. Our participants were Junior Wushu athletes in Modern Taolu who participated in the Second Modern Wushu Championship of Chile in 2022. The sample consisted of athletes with varying ages, years of training, genders, clubs, and anthropometric measurements. A detailed description of the sample characteristics will be provided in the Results section. This study was approved by the Institutional Board of the Chilienean Wushu Federation and followed the Declaration of Helsinki. Additionally, this research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (Navalta et al., 2019).

The Sit and Reach test (Eurofit) was used to assess hamstring flexibility in the studied groups. The test was conducted during the National Wushu Championship in Modern Taolu, where junior Wushu athletes participated. All measurements were taken before the athletes' competition events.

A standardized 10-minute warm-up was performed before the assessment. The test procedure was then explained to the participants and administered according to the appropriate protocol. The box utilized was 35 x 45 x 32 centimeters with starting measurement at the 15cm mark. Three trials were allowed for each individual with the maximum value used for statistical analysis. Finally, the test was conducted by two health trained professionals in the fields of physical therapy and physical education (HT & JS).

Statistical Analysis

Microsoft Excel was used to input the data. Subsequently, the data was imported into RStudio for statistical analysis using the R programming language (Rstudio, 2020). Descriptive statistics, including mean, standard deviation, median, minimum, and maximum, were calculated. To assess differences in Sit and Reach values between those who are and are not members of the national team, a linear mixed-effects model was used with the following formula: Sit n Reach ~ Team + Sex+ Age + Years of Practice + (1|Participant), where team, Sex, Age, and Years of Practice were used as fixed factors, while the participant was used as a random factor. An independent t-test was then performed between those who are part of the team and those who are not. The effect size of this difference was estimated using Cohen's D. To use Sit and Reach as a predictor of membership in the national team, a logistic regression was employed. Finally, to evaluate the predictive performance of this algorithm, a pseudo-R2 was calculated.

Results

The participants in this study were Junior Wushu athletes, with a total of 32 participants (females=13,male=19). The athletes were divided into two groups: those who were part of the national team (n=16) and those who were not (n=16). The sample was

further divided by sex, resulting in four subgroups: male athletes not in the team (n=10), male athletes in the team (n=9), female athletes not in the team (n=6), and female athletes in the team (n=7).

The overall mean age for athletes not in the team was 9.81 years (SD = 2.10), and for those in the team, it was 12.5 years (SD = 2.56). The mean weight for athletes not in the team was 43.0 kg (SD = 12.3), while for those in the team, it was 51.8 kg (SD = 14.9). The average height for athletes not in the team was 1.45 meters (SD = 0.134), and for those in the team, it was 1.56 meters (SD = 0.163). The mean BMI for athletes not in the team was 20.1 kg/m^2 (SD = 3.78), and for those in the team, it was 20.8 kg/m^2 (SD = 2.67). The average training experience for athletes not in the team was 1.38 years (SD = 1.15), while for those in the team, it was 4.06 years (SD = 2.89).

Regarding the Sit and Reach test, the mean score for athletes not in the team was 17.2 cm (SD = 6.69), and for those in the team, it was 29.4 cm (SD = 5.32). A more detailed breakdown of these values for each subgroup can be found in table 1.

A two-sample independent t-test was conducted to examine the differences in the Sit and Reach test scores between athletes who were part of the national team and those who were not. The results of the t-test indicated a statistically significant difference between the two groups ($t(28.5) = -5.72$, $p < 0.001$).

Athletes in the national team had a higher mean Sit and Reach score (M = 29.4 cm, SD = 5.32) compared to those not in the team (M = 17.2 cm, SD = 6.69). This finding suggests that junior Wushu athletes who are part of the national team have better hamstring flexibility. To further quantify the difference between the two groups, Cohen's d effect size

was calculated with Hedges' correction. The effect size (d = -1.97) indicates a large magnitude of difference between the national team athletes and non-team athletes in terms of hamstring flexibility. This suggests that the difference in Sit and Reach scores between the two groups is statistically significant and is practically meaningful (Figure 1).

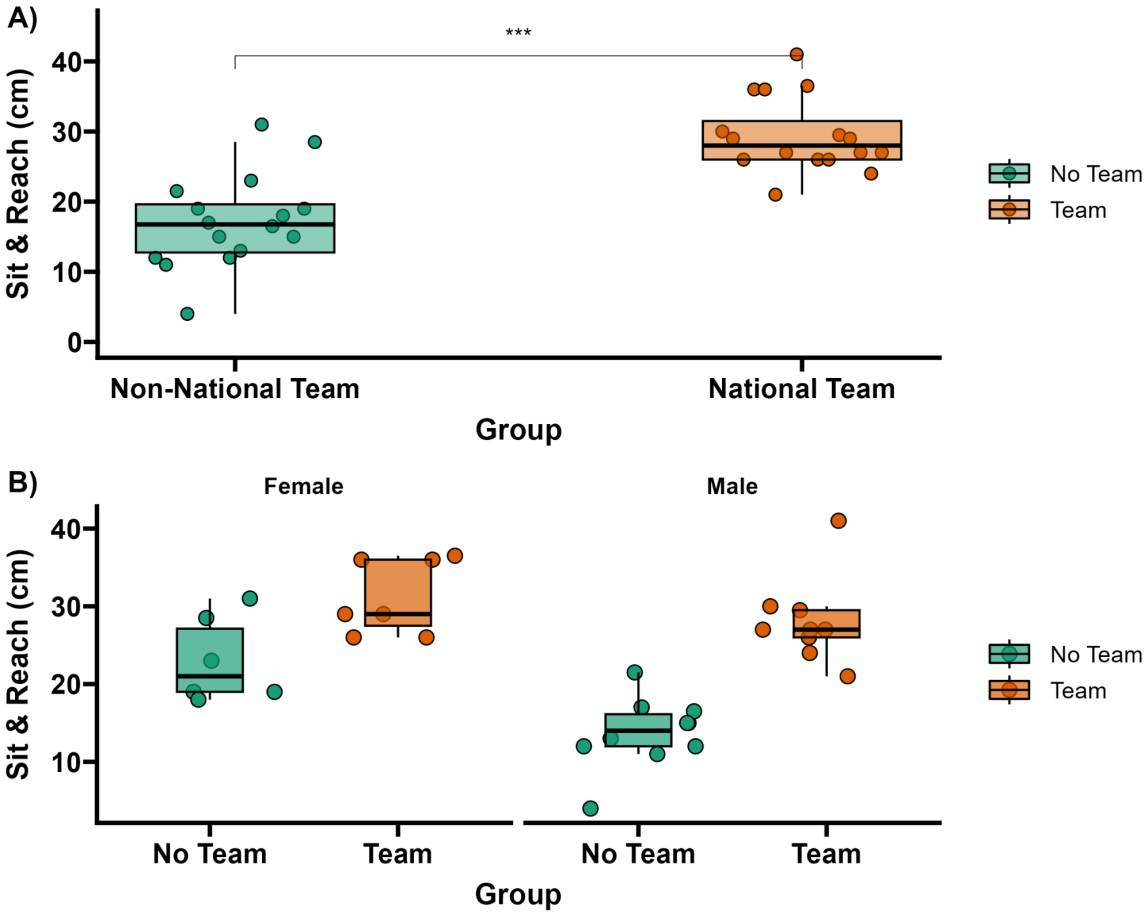

Figure 1. A) comparison of hamstring flexibility between groups; B) comparison between groups by sex.

A logistic regression analysis was conducted to predict group membership (national team or not) based on Sit and Reach test scores. The results of the logistic regression model were statistically significant (Intercept: Estimate = -8.6355, Std. Error = 3.0685, z = -2.814, p = 0.00489; Sit_Reach: Estimate = 0.3650, Std. Error = 0.1248, z = 2.926, p = 0.00344).

This indicates that the Sit and Reach test scores were effective in predicting whether junior Wushu athletes were part of the national team or not. The pseudo-R^2 was found to be 0.5199, suggesting that approximately 52% of the variance in group membership (national team or not) can be explained by the Sit and Reach test scores. This demonstrates a strong relationship between hamstring flexibility and being part of the national team in junior Wushu athletes.

Discussion

This study aimed to investigate the differences in hamstring flexibility between junior Wushu athletes who are part of the national team and those who are not. The results indicated significant differences in the Sit and Reach test scores between the two groups, with the national team athletes demonstrating greater flexibility. This finding supports the idea that hamstring flexibility may play an essential role in the performance of junior Wushu athletes, particularly at the national level.

The logistic regression analysis demonstrated that Sit and Reach test scores effectively predicted group membership (national team or not), with approximately 52% of the variance in group membership explained by hamstring flexibility. This finding suggests that hamstring flexibility may be a critical factor for junior Wushu athletes aspiring to join the national team. Notably, the highly decorated Beijing Wushu Team has implemented a flexibility test as part of their selection criteria. Furthermore, our results are consistent with observations in sports practice. Coaches and trainers can use this information to design targeted flexibility training programs aimed at enhancing athletes' chances of being selected for the national team.

Our study's findings are consistent with previous research on hamstring flexibility in athletes from various sports. For instance, a study found that karate athletes had significantly better hamstring flexibility than non-athletes, as measured by the Sit and Reach test (López-Miñarro et al., 2012). Similarly, another study reported that high-level soccer players exhibited greater hamstring flexibility compared to lower-level players (Muyor et al., 2014). Moreover, hamstring flexibility has been shown to be an essential factor for athletic performance in several sports, including gymnastics, dance, and martial arts (Lima et al., 2019; Wang et al., 2021). Improved flexibility can lead to better technique execution, reduced risk of injury, and enhanced overall performance (Witvrouw et al., 2003). Our study extends this research by focusing on junior Wushu athletes and demonstrating a significant difference in hamstring flexibility between those who are part of the national team and those who are not. This finding reinforces the importance of hamstring flexibility in athletic performance and highlights the need for targeted flexibility training in Wushu and other sports that require high levels of flexibility.

Our study employed the Eurofit Test Battery Sit and Reach protocol (Committee of Experts on Sports Research, 1988), wherein the "0" point for initiating measurements was positioned at 15 cm from the edge of the feet, differing from the ACSM protocol, which places it at 23 cm (9 inches) from the edge of the feet (Carrasco et al., 2013). To compare our results with other studies conducted using the ACSM protocol, we adjusted the corresponding values. Consequently, we observed that the adjusted mean values of Chilean Team athletes, at 37.4 cm, were similar to those found by Sukamti et al. in their study of 50 Indonesian wushu athletes aged between 8 and 15 years, who achieved 36 cm (Sukamti et al., 2022). The values for Chilean Non-Team athletes were lower than those found in this

study, at 25.2 cm. On the other hand, Huang et al. assessed 30 Taiwanese national ranking wushu athletes aged between 12 and 15 years, who had a mean of 47.6 cm, demonstrating a significant superiority compared to the values discovered in our Chilean study (Huang et al., 2016). Nonetheless, the values for Chilean wushu athletes in the Team from our research showed higher values than basketball athletes (mean = 31.5 cm), track and field athletes (mean = 30.47 cm), and general student athletes (mean = 30.27 cm) evaluated in Huang's study. An intriguing observation is that the values for Chilean junior wushu athletes, both Team and Non-Team, are considerably lower than the values found by Aedo-Muñoz in their study of 424 Chilean athletes aged between 12 and 18 years from various sports (aquatic sports, hunting, extreme sports, combat sports, team sports, track and field, and artistic gymnastics), which show mean values ranging between 45 and 53 cm for the evaluated athletes, even in those sports that do not require significant hamstring flexibility, such as hunting or team sports (Aedo-Muñoz et al., 2019). We believe that any discussion generated by comparing values with other authors should be approached cautiously, as the samples differ in size, age, training duration, and other factors. Moreover, in the case of our study, it should be considered that the evaluated athletes were only recently returning to competitions following the confinement due to the Covid-19 pandemic, and therefore their athletic performance level was not at its usual standard. Lastly, the discrepancy between scores could mostly be attributed to differences in protocols from both studies, the ACSM and the Eurofit Test Battery Sit and Reach protocol.

Limitations

There are several limitations to this study that should be acknowledged. First, the sample size was relatively small, which may limit the generalizability of the findings.

Future studies should aim to include a larger sample of athletes to validate the results. Second, the cross-sectional nature of the study prevents any causal inferences from being made. Longitudinal studies could help establish whether improvements in hamstring flexibility lead to increased chances of being selected for the national team or if athletes who are already part of the team tend to have better flexibility. Lastly, the study only focused on hamstring flexibility as a single factor influencing performance and national team selection. There may be other factors, such as technical skills, physical conditioning, or psychological attributes, that also contribute to an athlete's success. Future research should explore these factors in conjunction with hamstring flexibility to provide a more comprehensive understanding of the factors that influence performance in junior Wushu athletes.

Conclusion

Our study demonstrated that hamstring flexibility, as measured by the Sit and Reach test, was significantly different between junior Wushu athletes who were part of the national team and those who were not. Furthermore, hamstring flexibility was found to be an effective predictor of national team membership, suggesting its importance for performance in this population. These findings have implications for coaching and training programs, as they highlight the need to prioritize flexibility training for junior Wushu athletes aspiring to join the national team. Future research should aim to address the limitations of this study and explore additional factors that contribute to the performance and success of junior Wushu athletes.

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Table 1. Descriptive of Junior Wushu Athletes.

	Male		Female		Overall	
	No Team (N=10)	**Team (N=9)**	**No Team (N=6)**	**Team (N=7)**	**No Team (N=16)**	**Team (N=16)**
Age (yrs)						
Mean (SD)	9.40 (1.96)	12.7 (2.40)	10.5 (2.35)	12.3 (2.93)	9.81 (2.10)	12.5 (2.56)
Median [Min, Max]	10.0 [6.00, 11.0]	13.0 [9.00, 16.0]	12.0 [7.00, 12.0]	12.0 [9.00, 17.0]	10.5 [6.00, 12.0]	12.5 [9.00, 17.0]
Weight (kg)						
Mean (SD)	43.0 (11.0)	52.6 (17.9)	43.0 (15.4)	50.6 (11.4)	43.0 (12.3)	51.8 (14.9)
Median [Min, Max]	39.5 [31.3, 63.3]	47.0 [32.8, 85.0]	45.8 [22.0, 61.2]	49.0 [36.0, 68.1]	40.3 [22.0, 63.3]	48.0 [32.8, 85.0]
Height (m)						
Mean (SD)	1.43 (0.0989)	1.58 (0.194)	1.48 (0.186)	1.53 (0.118)	1.45 (0.134)	1.56 (0.163)
Median [Min, Max]	1.41 [1.29, 1.60]	1.50 [1.31, 1.86]	1.55 [1.18, 1.67]	1.52 [1.38, 1.71]	1.41 [1.18, 1.67]	1.51 [1.31, 1.86]
BMI (kg/m2)						
Mean (SD)	20.8 (4.05)	20.4 (2.39)	18.9 (3.24)	21.5 (3.07)	20.1 (3.78)	20.8 (2.67)
Median [Min, Max]	19.8 [16.3, 29.5]	20.1 [16.9, 24.8]	18.1 [15.8, 24.1]	23.3 [17.3, 24.6]	19.1 [15.8, 29.5]	20.6 [16.9, 24.8]
Training Experience (yrs)						
Mean (SD)	1.85 (1.23)	4.78 (3.35)	0.583 (0.204)	3.14 (2.04)	1.38 (1.15)	4.06 (2.89)
Median [Min, Max]	2.00 [0.500, 4.00]	4.00 [1.00, 10.0]	0.500 [0.500, 1.00]	3.00 [1.00, 7.00]	0.750 [0.500, 4.00]	3.00 [1.00, 10.0]
Sit & Reach (cm)						
Mean (SD)	13.7 (4.60)	28.1 (5.56)	23.1 (5.50)	31.2 (4.79)	17.2 (6.69)	29.4 (5.32)
Median [Min, Max]	14.0 [4.00, 21.5]	27.0 [21.0, 41.0]	21.0 [18.0, 31.0]	29.0 [26.0, 36.5]	16.8 [4.00, 31.0]	28.0 [21.0, 41.0]

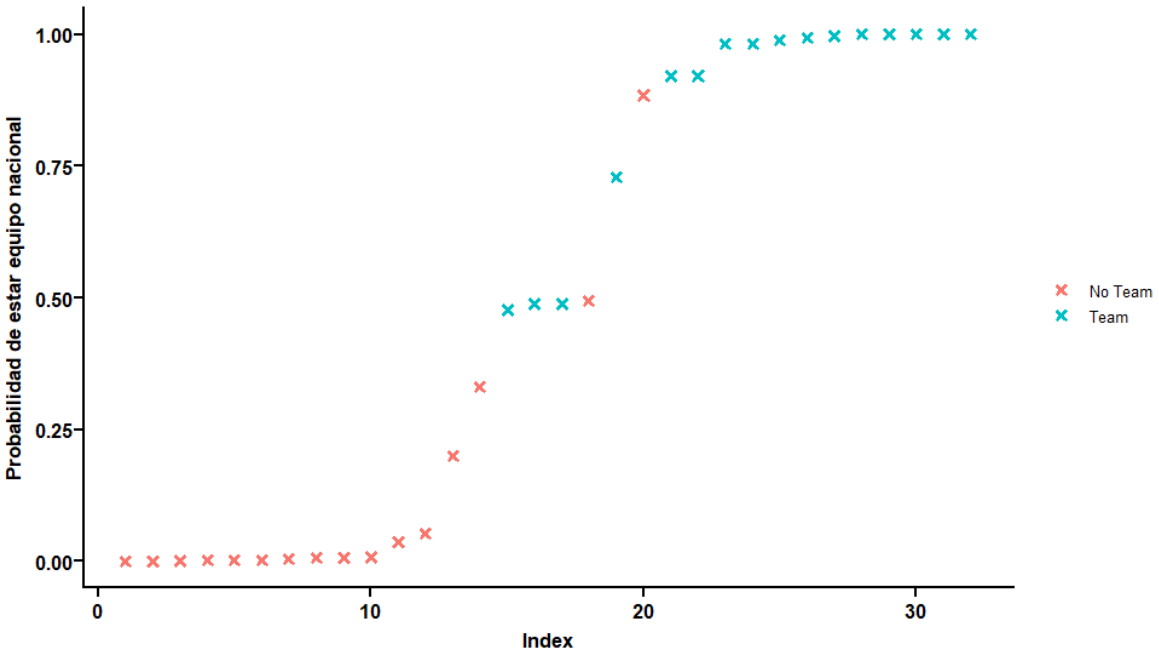

Figure S1. Logistic regression.