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Shoulder Flexibility Training on Agility and Biomechanical Efficiency in Badminton Smash Performance on a University in Shandong, China

Li Xiaolong

Emilio Aguinaldo College, Manila, Philippines

Abstract

This study examined the impact of shoulder flexibility training on agility and biomechanical efficiency in badminton smash performance among student-athletes from a university in Shandong, China. Using a descriptive, comparative, and correlational research design, data were gathered from 278 badminton players using a validated and reliable researcher-made questionnaire. Results indicated that athletes perceived their shoulder flexibility training as moderately effective in enhancing agility, particularly in improving range of motion and reflexive movements. Similarly, their biomechanical efficiency in smash performance was rated as "somewhat true," with shoulder and wrist flexibility and kinetic chain utilization receiving the highest scores. Statistical analysis revealed a strong and significant positive correlation ($r = 0.971$, $p < 0.01$) between shoulder flexibility training and biomechanical efficiency, confirming that increased flexibility contributes to more effective smash execution, postural control, and reduced muscular strain. These findings underscore the importance of incorporating targeted flexibility training into conditioning programs for badminton players. The study contributes empirical evidence supporting the integration of shoulder flexibility drills to enhance athletic performance and reduce injury risk in competitive badminton settings.

Keywords: Shoulder flexibility, agility, biomechanical efficiency, badminton smash, kinetic chain, sports performance, athletic training, university athletes, Shandong

INTRODUCTION

Badminton is a dynamic sport that demands physical prowess from players, especially when executing a powerful shot like the smash. This particular stroke is known for its offensive effectiveness and requires significant shoulder mobility to generate force and maintain control. When shoulder flexibility is compromised, athletes may experience restricted movement, slower racket velocity, and increased muscular tension, all of which can hinder stroke performance. Research indicates that enhanced shoulder mobility improves the function of the kinetic chain, allowing athletes to respond more quickly and deliver more forceful smashes. Moreover, studies have shown that core strength training, which supports the kinetic chain and trunk stability, significantly improves badminton players' performance in smashes, agility, and stroke control (Ma et al., 2024). This discussion focuses on how training for shoulder

flexibility, in tandem with core strength development, can support greater agility and biomechanical performance in badminton players, highlighting its importance in athletic development.

The biomechanics of a badminton smash involve a complex interplay of joint movements, with the shoulder acting as the primary rotational pivot (Wang et al., 2024). Efficient movement mechanics depend on a player's ability to achieve full shoulder abduction, external rotation, and rapid internal rotation during the downswing phase of the stroke (Huang et al., 2025). Research has demonstrated that athletes with superior shoulder mobility can generate greater angular velocity, leading to higher shuttlecock speeds and improved shot accuracy (Pardiwala et al., 2020). Without adequate flexibility, players may compensate by overusing other muscle groups, increasing the likelihood of injury and reducing biomechanical efficiency.

Agility, another crucial aspect of badminton performance, is closely linked to shoulder flexibility and upper-body mobility. Players must constantly shift positions to respond to opponents' shots, requiring rapid changes in direction and balance (Ghorpade et al., 2024). Research has shown that shoulder flexibility contributes to better postural control, allowing smoother weight transitions and reducing unnecessary muscle tension during movement (Wang & Zhou, 2024). Athletes with enhanced shoulder mobility tend to demonstrate quicker reflexes and better dynamic stability, which are essential for executing fast-paced smashes with minimal energy loss (Wang & Zhou, 2024).

From a biomechanical perspective, the transfer of energy in a badminton smash follows a kinetic chain, beginning from the lower limbs and culminating in the final acceleration of the racket head (Phomsoupha & Laffaye, 2015). Restricted shoulder range of motion (ROM) can disrupt this energy flow, resulting in inefficiencies that negatively affect shot velocity and precision (Couppé et al., 2014). Players with greater flexibility in their shoulders and thoracic spine are better able to execute follow-through movements efficiently, which reduces mechanical strain on the elbow and wrist (Heneghan et al., 2019). Enhanced mobility in these areas contributes to biomechanical efficiency, allowing players to sustain high-intensity rallies with reduced fatigue and risk of injury.

Given the various role of shoulder flexibility in badminton performance, this study seeks to investigate the impact of targeted shoulder flexibility training on the agility and biomechanical efficiency of student-athletes at a university in Shandong, China. By examining the functional relationship between shoulder mobility and smash execution, the research aims to inform evidence-based training interventions that enhance performance while minimizing injury risk. Therefore, this study aimed to explore the relationship between shoulder flexibility training, agility, and biomechanical efficiency in badminton smash performance. By assessing the impact of targeted flexibility interventions, the research seeks to provide empirical evidence supporting its integration into competitive training programs. The findings of this study may contribute to the development of more comprehensive and scientifically informed conditioning strategies in badminton.

METHODOLOGY

The study utilized a descriptive, comparative, and correlational methodology, recognized for its clear definitions, thorough documentation, rigorous analysis, and advanced understanding of contextual dynamics. It was conducted at a university in Shandong, China, specifically involving 278 badminton athletes from Shandong University of Political Science and Law. The respondents were selected using a purposive sampling technique, which targeted athletes who had engaged in badminton for at least one year. This sampling method ensured that only those with relevant experience participated in the study.

Regarding the research instrument, the researcher developed a questionnaire to gather data on the athletes' shoulder flexibility training, agility, and self-assessment of their biomechanical efficiency in badminton smash performance. The questionnaire was administered face-to-face or onsite.

The questionnaire consisted of three parts: Part 1 gathered demographic information of the badminton athletes; Part 2 assessed the athletes' shoulder flexibility training related to agility; and Part 3 focused on their self-assessment of biomechanical efficiency during badminton smash performance.

Both the adapted and researcher-made questionnaires underwent content validation by experts knowledgeable in the field. Their suggestions were incorporated into the instrument. Additionally, the instrument was subjected to face validation by at least five experts. Pilot testing was conducted to measure reliability, with results computed using Cronbach's Alpha via the Statistical Package for Social Sciences (SPSS). The researcher welcomed expert feedback and made necessary revisions to ensure validity.

The overall reliability of the questionnaire was very high, with a Cronbach's Alpha of 0.991, indicating consistent results across all items. This reliability test confirmed that the research instrument was statistically reliable.

Table 1

Summary Assessment of the Athlete Respondents of their Shoulder Flexibility Training on Agility

	Mean	**SD**	**QD**	**INT**	**Rank**
Range of Motion in Overhead Shots	1.86	.55	Somewhat True of Me	Somewhat True of My Training	**1.5**
Recovery Speed and Change of Direction	1.85	.56	Somewhat True of Me	Somewhat True of My Training	**3**
Shot Execution under Pressure	1.83	.56	Somewhat True of Me	Somewhat True of My Training	**4**
Reduction in Muscle Fatigue and Injury Risk	1.80	.28	Somewhat True of Me	Somewhat True of My Training	**5**
Reaction Time and Reflexive Movements	1.86	.55	Somewhat True of Me	Somewhat True of My Training	**1.5**
Overall	**1.84**	**.46**	**Somewhat True of Me**	**Somewhat True of My Training**	

Legend: 3.51-4.00 Very True of Me/ Very True of My Training; 2.51-3.50 True of Me/ True of My Training; 1.51-2.50 Somewhat True of Me/ Somewhat True of My Training 1.00-1.50 Not True of Me/ Not True of My Training

The summary assessment of the athlete respondents regarding their shoulder flexibility training on agility, as presented in Table 1, reveals that overall, the participants rated the impact of their training as "Somewhat True of Me" and "Somewhat True of My Training," with an average mean score of 1.84 and a standard deviation of 0.46. This indicates a moderate level of perceived effectiveness in how their shoulder flexibility training influences various aspects of agility.Specifically, the highest-rated factors were "Range of Motion in Overhead Shots" and "Reaction Time and Reflexive Movements," both sharing the top rank with mean scores of 1.86 and a standard deviation of 0.55. This suggests that athletes most strongly associate their shoulder flexibility training with improved range of motion and quicker reflexive responses during play.Following closely, "Recovery Speed and Change of Direction" received a mean score of 1.85, ranking third. This reflects that athletes perceive their training to moderately contribute to their ability to recover quickly and change directions efficiently on the court."Shot Execution under Pressure" was ranked fourth with a mean of 1.83, indicating a slightly lower but still moderate belief that shoulder flexibility training aids their performance in high-pressure situations. Lastly, "Reduction in Muscle Fatigue and Injury Risk" was rated the lowest, with a mean of 1.80 and the smallest standard deviation of 0.28. This suggests some consensus among respondents that while flexibility training may help reduce fatigue and injury risk, its impact in this area is perceived as less pronounced compared to other factors. Overall, the data suggests that the athletes recognize shoulder flexibility training as somewhat beneficial to their agility-related skills, particularly in enhancing range of motion and reflexive movements, while its perceived effect on muscle fatigue and injury prevention is comparatively lower.

Table 2
Summary Assessment of the Athlete Respondents of their Biomechanical Efficiency in Badminton Smash Performance

	Mean	**SD**	**QD**	**INT**	**Rank**
Kinetic Chain Utilization	1.85	.54	Somewhat True of Me	Somewhat True of My Training	**2**
Shoulder and Wrist Flexibility	1.86	.57	Somewhat True of Me	Somewhat True of My Training	**1**
Timing and Contact Point	1.84	.54	Somewhat True of Me	Somewhat True of My Training	**3.5**
Body Balance and Posture	1.84	.57	Somewhat True of Me	Somewhat True of My Training	**3.5**
Recovery Efficiency	1.82	.55	Somewhat True of Me	Somewhat True of My Training	**5**
Overall	**1.84**	**.53**	**Somewhat True of Me**	**Somewhat True of My Training**	

Legend: 3.51-4.00 Very True of Me/ Very True of My Training; 2.51-3.50 True of Me/ True of My Training; 1.51-2.50 Somewhat True of Me/ Somewhat True of My Training 1.00-1.50 Not True of Me/ Not True of My Training

Among the five domains, Shoulder and Wrist Flexibility ranked highest (M = 1.86), suggesting that athletes recognize this area as a key contributor to their smash execution, likely due to its role in precision,

power, and control.Kinetic Chain Utilization followed closely (M = 1.85), indicating that athletes are aware of the importance of coordinated body movements, from the legs to the upper body, in optimizing power transfer during the smash. Timing and Contact Point and Body Balance and Posture both scored a mean of 1.84, reflecting athletes' moderately confident perceptions of their ability to strike the shuttle accurately and maintain posture throughout the action.

Recovery Efficiency received the lowest mean (M = 1.82), which, while still rated positively, suggests a relatively weaker area where athletes may face more difficulty transitioning smoothly into the next move after a smash. The overall composite mean of 1.84 confirms a consistent perception across all aspects, pointing to a solid but improvable level of biomechanical efficiency in their badminton smash performance

Table 3

Relationship between the Assessment of the Athlete Respondents of their Shoulder Flexibility Training on Agility and Assessment of the Athlete Respondents of their Biomechanical Efficiency in Badminton Smash Performance

Variable	Profile	Computed r	Sig	Decision on Ho	Interpretation
Range of Motion in Overhead Shots	Kinetic Chain Utilization	.888	.000	Rejected	Significant
	Shoulder and Wrist Flexibility	.890	.000	Rejected	Significant
	Timing and Contact Point	.900	.000	Rejected	Significant
	Body Balance and Posture	.885	.000	Rejected	Significant
	Recovery Efficiency	.895	.000	Rejected	Significant
	Total	.933	.000	Rejected	Significant
Recovery Speed and Change of Direction	Kinetic Chain Utilization	.894	.000	Rejected	Significant
	Shoulder and Wrist Flexibility	.909	.000	Rejected	Significant
	Timing and Contact Point	.896	.000	Rejected	Significant
	Body Balance and Posture	.889	.000	Rejected	Significant
	Recovery Efficiency	.906	.000	Rejected	Significant
	Total	.940	.000	Rejected	Significant

Shot Execution under Pressure	Kinetic Chain Utilization	.885	.000	Rejected	Significant
	Shoulder and Wrist Flexibility	.889	.000	Rejected	Significant
	Timing and Contact Point	.887	.000	Rejected	Significant
	Body Balance and Posture	.888	.000	Rejected	Significant
	Recovery Efficiency	.896	.000	Rejected	Significant
	Total	.930	.000	Rejected	Significant
Reduction in Muscle Fatigue and Injury Risk	Kinetic Chain Utilization	.576	.000	Rejected	Significant
	Shoulder and Wrist Flexibility	.569	.000	Rejected	Significant
	Timing and Contact Point	.573	.000	Rejected	Significant
	Body Balance and Posture	.565	.000	Rejected	Significant
	Recovery Efficiency	.555	.000	Rejected	Significant
	Total	.594	.000	Rejected	Significant
Reaction Time and Reflexive Movements	Kinetic Chain Utilization	.883	.000	Rejected	Significant
	Shoulder and Wrist Flexibility	.894	.000	Rejected	Significant
	Timing and Contact Point	.884	.000	Rejected	Significant
	Body Balance and Posture	.881	.000	Rejected	Significant
	Recovery Efficiency	.883	.000	Rejected	Significant
	Total	.926	.000	Rejected	Significant
Overall Shoulder Flexibility Training	Overall Biomechanical Efficiency in Badminton Smash Performance	.971	.000	Rejected	Significant

on Agility					

The analysis reveals significant positive relationships between the athlete respondents' assessment of their shoulder flexibility training on agility and their assessment of biomechanical efficiency in badminton smash performance across all variables. The computed correlation coefficients (r) for each pair of variables range from moderate to very strong, all exceeding 0.5, with the highest correlation observed between the overall shoulder flexibility training on agility and the overall biomechanical efficiency in badminton smash performance ($r = 0.971$).

For each specific variable, such as range of motion in overhead shots, recovery speed and change of direction, shot execution under pressure, reduction in muscle fatigue and injury risk, and reaction time and reflexive movements, the correlations with the components of biomechanical efficiency like kinetic chain utilization, shoulder and wrist flexibility, timing and contact point, body balance and posture, and recovery efficiency were all found to be significant, with p-values of 0.000. These results suggest that improvements in shoulder flexibility training positively impact the athletes' biomechanical efficiency across multiple facets of badminton smash performance.

The null hypothesis (Ho) that there is no significant relationship between shoulder flexibility training and biomechanical efficiency in badminton smash performance is rejected for all cases, as the computed r values are statistically significant at a 1% level. This indicates that shoulder flexibility training on agility is strongly associated with the athletes' ability to perform efficiently in various biomechanical aspects of the badminton smash, and the overall relationship between the two constructs is robust and significant.

Conclusion

The findings of this study indicate that shoulder flexibility training is crucial for enhancing both agility and biomechanical efficiency in badminton smash performance. At a university in Shandong, China, student-athletes' self-evaluations indicated that shoulder flexibility training was moderately beneficial in improving key aspects of agility, such as range of motion, response speed, and directional change. Athletes reported moderate levels of biomechanical efficiency, particularly with shoulder and wrist flexibility, utilization of the kinetic chain, and timing of contact.

The significant positive correlations among all variables indicate that enhanced shoulder flexibility is associated with superior biomechanical performance, including improved posture, coordination, and energy transfer during smashes. The robust correlation ($r = 0.971$) between comprehensive shoulder flexibility training and overall biomechanical efficiency strongly advocates for the inclusion of flexibility training in athletic conditioning programs.

This study affirms that badminton training must emphasize targeted shoulder flexibility exercises. This will enhance performance in high-intensity movements such as the smash, reduce the likelihood of injury, and facilitate athletes' development over time. These insights are invaluable for coaches, trainers, and sports educators seeking to develop comprehensive and evidence-based training regimens for badminton players.

Reference

1. Couppé, C., Thorborg, K., Hansen, M., Fahlström, M., Bjordal, J. M., Nielsen, D., Baun, M., Storgaard, M., & Magnusson, S. P. (2014). Shoulder rotational profiles in young healthy elite female

and male badminton players. Scandinavian Journal of Medicine & Science in Sports, 24(1), 122–128. https://doi.org/10.1111/j.1600-0838.2012.01480.x

2. Heneghan, N. R., Webb, K., Mahoney, T., & Rushton, A. (2019). Thoracic spine mobility, an essential link in upper limb kinetic chains in athletes: A systematic review. Translational Sports Medicine, 2(4), 126–138. https://doi.org/10.1002/tsm2.109
3. Huang, H., Guo, Z., Zhao, M. et al. Differences in backcourt forehand clear stroke between novice players and experienced badminton players: based on body segment acceleration data. BMC Sports Sci Med Rehabil **17**, 118 (2025). https://doi.org/10.1186/s13102-025-01163-w
4. Ghorpade, O. S., Rizvi, M. R., Sharma, A., Almutairi, H. J., Hasan, S., Shaik, A. R., … Alghadir, A. H. (2024). Enhancing physical attributes and performance in badminton players: Efficacy of backward walking training on treadmill. BMC Sports Science, Medicine and Rehabilitation, 16, 170. https://doi.org/10.1186/s13102-024-00962-x
5. Ma, S., Soh, K. G., Japar, S. B., Liu, C., Luo, S., Mai, Y., Wang, X., & Zhai, M. (2024). Effect of core strength training on the badminton player's performance: A systematic review & meta-analysis. PLOS ONE, 19(6), e0305116. https://doi.org/10.1371/journal.pone.0305116
6. Pardiwala, D. N., Subbiah, K., Rao, N., & Modi, R. (2020). Badminton Injuries in Elite Athletes: A Review of Epidemiology and Biomechanics. Indian journal of orthopaedics, 54(3), 237–245. https://doi.org/10.1007/s43465-020-00054-1
7. Phomsoupha, M., & Laffaye, G. (2015). The science of badminton: Game characteristics, anthropometry, physiology, visual fitness and biomechanics. Sports Medicine (Auckland, N.Z.), 45(4), 473–495. https://doi.org/10.1007/s40279-014-0287-2
8. Wang, B., & Zhou, H. (2024). Study on the impact of shoulder flexibility training on smash speed mechanics in badminton using machine learning. Molecular & Cellular Biomechanics, 21(2), 375. https://doi.org/10.62617/mcb.v21i2.375
9. Wang, Y., Xu, L., Jiang, H., Yu, L., Wu, H., & Mei, Q. (2024). Biomechanical Effects of the Badminton Split-Step on Forecourt Lunging Footwork. Bioengineering, 11(5), 501. https://doi.org/10.3390/bioengineering11050501