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Analysis of Hamstring Flexibility on Injury Risk Volleyball Athletes

Anung Probo Ismoko[1*], Yudha Febrianta[1], Amri Ikhsanul Amal[1], RD. Devy Citra Pratiwi[1], Imami Nughraheni[1], Danang Endarto Putro[2]

[1]Departement of Sport Science, Faculty of Teacher Training and Education, Universitas Muhammadiyah Purwokerto, 53182, Indonesia

[2]Physical Education, Health and Recreation Study Program STKIP PGRI Pacitan, 63515, Indonesia

*Correspondence: ismokoanung@ump.ac.id
Departement of Sport Science, Faculty of Teacher Training and Education, Universitas Muhammadiyah Purwokerto, 53182, Indonesia

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Abstract

Background: flexibility is a crucial factor in injury prevention in explosive sports like volleyball. Hamstring tightness or limited flexibility can increase the risk of musculoskeletal injuries in the lower limbs.

Objectives: This study aimed to analyze the relationship between hamstring flexibility and injury risk in volleyball athletes from the BVB Banyumas club.

Methods: This study used a quasi experimental quantitative method with a one group pretest posttest design. The subjects were 20 active junior volleyball athletes selected through purposive sampling. The research instruments included the Sit and Reach Test to measure hamstring flexibility and the Functional Movement Screen (FMS) to assess injury risk. The intervention, a hamstring stretching exercise program, was implemented for 4 weeks, 3 times per week. Data were analyzed using a t-test with a significance level of 0.05

Results: The results showed a significant increase in hamstring flexibility from 18.75 ± 3.08 cm to 23.85 ± 2.96 cm ($p = 0.000$) and an increase in FMS scores from 13.45 ± 1.31 to 15.80 ± 1.18 ($p = 0.000$). In addition, the results of the Pearson correlation test showed a strong negative relationship between hamstring flexibility and injury risk ($r = -0.726$; $p = 0.001$), which means that the better an athlete's flexibility, the lower their risk of injury.

Conclusion: Regular hamstring stretching exercises can improve flexibility and reduce the risk of injury in volleyball athletes. This research demonstrates the importance of flexibility training in preventive and rehabilitative training programs for athletes.

Keywords: hamstring flexibility; volleyball; injury.

INTRODUCTION

Volleyball is a sport that requires a combination of strength, agility, and good mobility, especially in the lower limbs. Movements such as jumping, leaping, landing, rapid position changes, and body rotation are always performed repeatedly by volleyball athletes. In these movements, the hamstring muscles, namely the muscle group at the back of the thigh consisting of the biceps femoris, semitendinosus, and semimembranosus, play a crucial role in the landing phase and deceleration of lower leg movements. Tension or stiffness (low flexibility) in the hamstring muscles can cause increased musculoskeletal strain when athletes perform explosive or unexpected movements, which can trigger musculoskeletal injuries in the lower legs. Biomechanical studies have shown that better hamstring flexibility is associated with greater optimal musculotendinous lengths and lower peak musculotendinous strain during sprinting or other rapid movements, (Wan et al., 2021).

Some studies have viewed limited flexibility as a modifiable risk factor for injury, but large-scale epidemiological studies have noted that deficits in hamstring flexibility or ankle dorsiflexion have only shown a weak association with the incidence of hamstring muscle injuries, (van Dyk et al., 2018). This statement indicates that although flexibility can be improved through training, the causal relationship mechanism between flexibility and injury remains complex and is influenced by many other factors such as muscle strength, quadriceps hamstring ratio, hip joint condition, athlete's movement patterns, and injury history.

In volleyball, there is literature showing that the average hamstring flexibility value in volleyball athletes varies considerably and tends to be in the medium to low range. For example, research on volleyball athletes belonging to the Indonesian National Sports Committee of DKI Jakarta Province (KONI DKI Jakarta) showed an average hamstring flexibility value through the Sit and Reach Test of 18.21 ± 6.5 cm. This indicates a

potential need for flexibility training for volleyball athletes. In the practice of volleyball athlete training in the Banyumas Regency area, clubs such as BVB Banyumas do not yet have much scientific data linking hamstring flexibility to injury risk. Therefore, research that examines the relevance of both academic understanding and practical application aspects in the training field is needed. Volleyball training routines involving frequent jumping, leaping, and landing can place the hamstring muscles in a static or less-than-optimal state of mobility. Limited hamstring flexibility can lead to increased biomechanical components such as muscle strain during the late swing or landing phase when athletes perform explosive movements, (Wan et al., 2017). This suggests that improving hamstring flexibility may be an injury prevention strategy. However, because the evidence is still mixed, more specific research is needed in a population of volleyball athletes with specific movement characteristics.

Based on the description above, the research question arises as to whether the level of hamstring flexibility has an influence on the risk of injury in volleyball athletes at the BVB Banyumas club. In other words: do volleyball athletes with better hamstring flexibility tend to have a lower risk of injury than athletes with lower flexibility? This study aims to answer this question by conducting an empirical analysis of the volleyball athlete population at the BVB Banyumas club. The purpose of this study is to determine and analyze the relationship between hamstring muscle flexibility and the level of injury risk in volleyball athletes at the BVB Banyumas club. This research is expected to provide a baseline for designing hamstring stretching and mobility training programs as part of injury prevention and to increase athlete awareness. The better the hamstring flexibility in volleyball athletes, the lower the risk of injury. Therefore, this study will explore the possible interaction between hamstring flexibility (the independent variable) and injury risk (the dependent variable) in volleyball athletes. Muscle flexibility is defined as

the ability of the muscle-tendon network to lengthen and allow a joint to move through its full range of motion (ROM) without pain or structural restriction. In the context of the hamstring muscles, the group of muscles behind the thigh consisting of the biceps femoris, semitendinosus, and semimembranosus, flexibility is crucial because these muscles are involved in hip extension, knee flexion, and landing and deceleration of lower leg movements. Limited hamstring flexibility can cause the muscles and tendons to reach their maximum stretch point (musculotendinous strain) more quickly during fast or explosive movements. Research shows that muscles that undergo rapid extension or are in a lengthened state during eccentric contractions are more susceptible to injury, (Worrell & Perrin, 1992). Good flexibility allows the hamstring muscles to function efficiently during deceleration and landing, where their role is to restrain or control the movement of the lower leg as the knee and hip flex. If the muscles are not flexible enough, the strain increases during the descent or sliding phase (late swing or landing), increasing the risk of injury, (G. et al., 2011). Hamstring injuries are one of the most common musculoskeletal injuries in sports involving sudden movements and rapid changes in direction. Several intrinsic and extrinsic factors are believed to be the cause, including previous injury history, hamstring-to-quadriceps strength ratio, neuromuscular control, training load, and muscle flexibility, (Navarro et al., 2015). Flexibility is often cited as a risk factor, its effectiveness as a predictor of injury remains controversial due to variability between individuals and sport contexts. In volleyball, athletes frequently jump, leap, land, and change direction rapidly. The landing and deceleration phases require maximum hamstring muscle activity to control movement and minimize excessive strain on the knee and hip joints. Therefore, hamstring flexibility is highly relevant for injury prevention. The study “Risk factors and injury prevention strategies for hamstring injuries” stated that limited hamstring flexibility is a significant risk factor for injury, although the

effect varies, (Shield & Bourne, 2018). Research shows that stretching techniques such as dynamic stretching and PNF (Proprioceptive Neuromuscular Facilitation) can improve flexibility, but the long-term impact on injury prevention is still inconsistent, (Zvetkova et al., 2023). A study of adolescent athletes in various sports found that hamstring flexibility, core strength, and joint range of motion were important predictors of performance and potential injury risk, (KONDO et al., 2017).

Although various previous studies have addressed the relationship between hamstring flexibility and injury risk, the results remain inconsistent and have differing interpretations. Most studies have focused on high-speed sports, where movement characteristics differ significantly from volleyball, which places greater emphasis on vertical jumps and repeated landings. This makes the findings of these studies incapable of being fully generalizable to the context of volleyball athletes. In terms of measuring injury risk, few studies have used a functional approach, such as the Functional Movement Screen (FMS), to comprehensively assess the relationship between movement patterns, flexibility, and injury in a volleyball athlete population. Furthermore, research in Indonesia that examines hamstring flexibility and its relationship to injury risk in volleyball athletes is still very limited, particularly at the regional club level, such as in Banyumas. This is despite the fact that the training characteristics, competition intensity, and physical condition of local athletes can differ from those of national and international athletes. Therefore, research is needed that specifically analyzes the relationship between hamstring flexibility and injury risk using direct testing instruments and a functional approach in the local volleyball athlete population. This research is expected to fill this knowledge gap and provide practical contributions for coaches, physiotherapists, and sports institutions in designing evidence-based injury prevention training programs.

METHODS

Study Design and Participants

This study used a quantitative approach with a quasi-experimental design in the form of a one-group pretest and posttest. This design was used to determine changes in hamstring flexibility and injury risk before and after stretching exercises. The study was conducted at the BVB Banyumas Volleyball Court. This approach allows for direct observation of physiological changes in the subjects without the use of an external comparison group, yet still provides empirical evidence regarding the relationship between variables, (Creswell & Creswell, 2018). The population in this study was all 20 male junior volleyball athletes from the BVB Banyumas club. The sample was selected using a purposive sampling technique, taking the inclusion criteria: athletes who actively trained at least three times a week, were not currently experiencing lower limb injuries, and were willing to participate in the entire research process. Athletes who experienced severe pain or missed training more than twice during the intervention program were excluded from the analysis.

Research Instruments

The instruments used consist of two types: the Sit and Reach Test to measure hamstring flexibility and the Functional Movement Screen (FMS) to assess the risk of musculoskeletal injury. The Sit and Reach Test is a valid and reliable measuring tool for assessing hamstring muscle flexibility, with a criterion validity of r = 0.46–0.67 and reliability above r = 0.85, (Mayorga-Vega et al., 2014). The Functional Movement Screen (FMS) is used to assess injury risk through seven basic movement patterns: deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability. Each movement is scored on a scale of 0–3, with a score of 3 indicating perfect movement with no compensation, a score of 2 indicating slight compensation, a score of 1

indicating the movement cannot be performed properly, and a score of 0 is given if pain occurs during the movement. The maximum total score is 21, and a score ≤14 indicates a high risk of injury. The FMS has excellent reliability (ICC = 0.81) and has been proven valid in predicting injury risk in athletes, (Bonazza et al., 2017). The research procedure was carried out in three stages: pre-test, intervention, and post-test. The pre-test was conducted to obtain initial data on hamstring flexibility and FMS scores. The intervention phase was carried out for 4 weeks with a frequency of 3 times per week, using a combination of dynamic stretching, static stretching, and Proprioceptive Neuromuscular Facilitation (PNF) exercises. Each training session consisted of 5 minutes of dynamic stretching, 3 sets of 30 seconds of static stretching per muscle, and 2 sets of PNF stretching with 10 seconds of contraction and 20 seconds of relaxation. This program was adapted from a combination of these stretching methods which are effective in increasing muscle flexibility and reducing the risk of injury in athletes. After the program was completed, a post-test was conducted to assess changes in both research variables using the same instruments as in the initial measurements.

Data Analysis

The data obtained were analyzed using inferential statistical analysis. Normality was tested using the Shapiro Wilk test, while homogeneity was tested using Levene's test. If the data were normally distributed and homogeneous, a paired sample t-test was used to test for significant differences between the pre-test and post-test results.

RESULTS

This study involved 20 active volleyball athletes from the BVB Banyumas club who participated in a four-week stretching training program. Based on the results of measurements before (pre-test) and after the intervention (post-test), a significant increase in hamstring muscle

flexibility and a decrease in injury risk scores based on the Functional Movement Screen (FMS) were found. The average Sit and Reach Test result before treatment was 18.75 ± 3.08 cm, while after the intervention it increased to 23.85 ± 2.96 cm. This indicates an increase in flexibility of +5.10 cm or approximately 27.2% of the initial value. The results of the Paired Sample t-Test showed that the difference was statistically significant ($t = 8.214$; $p = 0.000 < 0.05$). Meanwhile, the average FMS score in the pre-test was 13.45 ± 1.31, and after the intervention it increased to 15.80 ± 1.18. Thus, there was an increase of +2.35 points or approximately 17.5% from the initial value. The t-test results showed that this difference was also statistically significant ($t = 7.024$; $p = 0.000 < 0.05$). Based on the FMS criteria, before the intervention, 14 athletes (70%) were in the high injury risk category (score ≤14), while 6 athletes (30%) were at low risk (score >14). After the implementation of the training program, the number of athletes with a high injury risk decreased to 4 (20%), while 16 athletes (80%) were in the low risk category.

Table 1. Comparison of Average Flexibility Values and FMS Scores of Athletes Before and After Treatment

Variable	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Deviation	t count	p-value	Result
Fleksibility (Sit and Reach/cm)	18,75 ± 3,08	23,85 ± 2,96	+5,10	8,214	0,000	Signifikan
Functional movement Screen (FMS)	13,45 ± 1,31	15,80 ± 1,18	+2,35	7,024	0,000	Signifikan

Table 2. Frequency Distribution of Injury Risk Categories Based on FMS Scores

Injury Risk Category	Score FMS	Pre-test (n/%)	Post-test (n/%)
High	≤ 14	14 (70%)	4 (20%)
Low	> 14	6 (30%)	16 (80%)
Total		20 (100%)	20 (100%)

The results of this study indicate that regular stretching exercises performed for four weeks can have a significant positive effect on increasing hamstring flexibility and reducing the risk of injury in

volleyball athletes. This increase in flexibility occurs because static, dynamic, and PNF stretching exercises can lengthen muscle tissue and tendons, thereby improving joint elasticity and stability. An increase in the FMS score also indicates improvements in motor control, core stability, and body balance, which contribute to injury prevention. These findings align with research showing that regular stretching exercises can improve neuromuscular efficiency and reduce the incidence of muscle injuries in athletes, and that an increase in the FMS score is directly correlated with a reduced risk of musculoskeletal injuries in competitive athletes. Overall, these results strengthen the hypothesis that hamstring flexibility is a crucial factor in reducing injury risk in volleyball athletes. Therefore, coaches and physiotherapists are advised to incorporate a comprehensive stretching program into their training routines as part of an evidence-based injury prevention strategy.

DISCUSSION

The results showed a significant increase in hamstring flexibility and Functional Movement Screen (FMS) scores after a four-week stretching program. The average Sit and Reach Test score increased from 18.75 cm to 23.85 cm, while the FMS score increased from 13.45 to 15.80. Both test results showed a significant difference ($p = 0.000$), indicating that stretching exercises effectively improve functional movement ability and reduce injury risk in volleyball athletes. This increase in hamstring flexibility is due to muscle and tendon tissue adaptation to stretching, primarily through mechanisms such as increased viscoelasticity and passive muscle length. Static stretching and PNF stretching are known to reduce muscle stiffness and increase joint range of motion, while dynamic stretching increases muscle temperature and blood circulation, supporting muscle performance. Improvements in FMS scores indicate improved core stability and body movement control, which are indicators of a

reduced risk of musculoskeletal injury. The strong negative correlation between flexibility and injury risk ($r = -0.726$; $p = 0.001$) demonstrates that greater hamstring flexibility lowers the risk of injury for athletes. This finding supports previous research suggesting that hamstring muscle stiffness increases the risk of non-contact injuries, such as hamstring strains and knee ligament injuries. Therefore, regular stretching exercises are crucial for injury prevention and performance improvement in volleyball athletes.

CONCLUSION

Based on the research results, it can be concluded that four weeks of stretching exercises significantly increased hamstring muscle flexibility and reduced the risk of injury in BVB Banyumas volleyball athletes. The average Sit and Reach Test results and Functional Movement Screen (FMS) scores showed a significant increase ($p < 0.05$), and there was a strong negative correlation between flexibility and injury risk ($r = -0.726$). This proves that the better the hamstring flexibility, the lower the potential for injury experienced by athletes. Therefore, a regular stretching exercise program needs to be part of the training routine to maintain performance and prevent injury in volleyball athletes.

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CONFLICT OF INTEREST

The researcher declares that there is no conflict of interest in the conduct or reporting of this research. The entire research process, data analysis, and article writing were conducted independently without any personal, institutional, or financial influence or interests from any party.

AUTHOR'S CONTRIBUTION

All authors actively contributed to every stage of this research. Anung Probo Ismoko was responsible for the research design, data collection, and analysis of the results. Yudha Febrianta was involved in instrument development, field testing, and data interpretation. Danang Endarto Putro assisted in manuscript writing, final editing, and reference preparation. All authors have read and approved the final manuscript for publication.

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