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Implementation of Preventive Physical Exercises to Reduce Knee and Wrist Injuries in Volleyball Athletes

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A. Conception and design of the study; **B.** Acquisition of data;
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ABSTRACT

Knee and wrist injuries are two common problems experienced by volleyball athletes, primarily due to jumping, landing, and repetitive upper extremity movements. This study aims to assess the effectiveness of implementing a preventive physical training program in reducing the frequency and risk of knee and wrist injuries in volleyball athletes at the BKMF FIKK UNM. The study used a quantitative approach with a pretest-posttest control group design. The sample consisted of 30 active athletes who had been participating in training for at least 3 months. The intervention was administered for 8 weeks, three times per week, and included core stabilization exercises, knee and wrist muscle strengthening, proprioception, and landing technique. Data were collected through injury questionnaires, handgrip strength tests, single-leg balance tests, and observations of landing technique. The results showed a reduction in the frequency of knee injuries from 60% to 30%, and wrist injuries from 43% to 20%. Wrist strength increased from 28.7 kg to 32.5 kg, and leg balance time increased from 21.3 seconds to 26.4 seconds. A paired-sample t-test showed significant results ($p < 0.05$), and an effect size (Cohen's d) value > 0.8 indicated a large effect. In conclusion, the preventive physical training program has been shown to be statistically and practically effective in reducing injuries and improving physical performance. This intervention is recommended for continued implementation in collegiate athletic training environments.

Keywords : Preventive Physical Exercise; Knee Injury; Wrist Injury; Volleyball Athlete; Injury Prevention.

INTRODUCTION

Volleyball is a popular team sport and is actively played at various levels of education, including professional clubs. Typical movements such as jumping, blocking, smashing, serving, and rapid changes of direction require athletes to possess excellent physical capacity, as well as high levels of coordination and balance. This places significant biomechanical stress on both the lower and upper joints, including the knees and wrists. Research shows that musculoskeletal injuries, including lower and upper joint injuries, are a fairly common health problem in volleyball athletes, both at the amateur and competitive levels (Gouttebarge et al., 2017).

Injuries not only impact athlete performance in training and matches, but can also disrupt training continuity, lead to absences, incur significant rehabilitation costs, and have

psychological consequences. Therefore, injury prevention through preventive physical training is a crucial strategy in athlete health management. For example, prevention programs involving neuromuscular training, core strength, proprioception, and dynamic stability have been shown to be effective in reducing the risk of lower extremity injuries in team sports (Gouttebarge et al., 2017).

In the context of volleyball, the knee joint is a frequent site of injury due to repetitive jumping and landing, while the upper extremity (including the wrist) is also prone to injury due to serving, blocking, and contact with the ball or the floor. Recent epidemiological studies report a high proportion of upper extremity injuries (including the wrist) in young volleyball players. For example, Obana et al. (2024) found that the wrist accounted for approximately 22.8% of upper extremity injuries in volleyball players aged 18 years and under.

Therefore, it is understandable that injury prevention through targeted physical training is an urgent need so that athletes can train and compete with a lower risk of injury and reach their maximum potential.

More specifically, indoor volleyball athletes undergo training and competition regimens that require numerous vertical jumps, rapid landings, changes of direction, and intensive upper extremity use. This causes the knee to experience significant compressive and rotational forces during the landing phase, increasing the risk of injuries such as ligament injuries, patellofemoral pain syndrome, and tendinopathy (Farokhi & Fatahi, 2024). Furthermore, suboptimal landings or poor technique can lead to dangerous valgus/varus moments in the knee (Farokhi & Fatahi, 2024).

Furthermore, the wrist is also susceptible to injury due to contact with the ball, falls to the floor, or repetitive movements during serves and overhead passes. For example, Obana et al. (2024) stated that the wrist is one of the most common injury sites in young volleyball players. Furthermore, Milic et al. (2025) confirmed in their study that lower extremity injuries predominate, but the upper extremity, including the wrist, cannot be ignored in volleyball.

Preventive physical training programs that include core muscle strength training, stability training, proprioception, and landing technique have been studied in the context of knee and lower extremity injuries. For example, Gouttebarge et al. (2017) suggested that structured prevention programs can reduce lower joint injuries in volleyball and related sports. However, the implementation of comprehensive prevention programs for the upper joints (including the wrist) in the context of volleyball athletes is still limited.

In academic settings such as the BKMF FIKK UNM (Student Activity Body of the Faculty of Sport Sciences, Makassar State University), volleyball athletes have not been systematically studied regarding the implementation of specific preventive physical training to reduce knee and wrist injuries. Risk factors such as poor landing technique, lack of joint stability training, excessive training loads, fatigue, and inadequate warm-up/prevention protocols are relevant factors for mitigation. Epidemiological studies show that although injuries are preventable, many teams still do not systematically implement prevention programs (Milic et al., 2025). Therefore, it is highly relevant to conduct research examining how the implementation of comprehensive preventive physical training can contribute to reducing knee and wrist injuries in volleyball athletes within the BKMF FIKK UNM environment.

Based on the above description, several key issues addressed in this study are as follows: (1) The high incidence of knee and wrist injuries among volleyball athletes in the BKMF FIKK UNM environment, which can hinder training and competitive performance, (2) The lack of implementation of specific and systematic preventive physical training programs to reduce the risk of these injuries, (3) The lack of knowledge or limited empirical data in

the local environment (campus/university) regarding the effectiveness of preventive physical training in the context of knee and wrist injuries in volleyball athletes, and (4) The need to design and evaluate preventive physical training interventions that can be practically implemented by coaches and athletes in the BKMF FIKK UNM environment, thereby reducing injury rates and improving training continuity and performance.

This study will address these issues by implementing structured preventive physical training and then measuring its impact on the incidence of knee and wrist injuries. The primary focus will be not only on the design of the training program, but also on its implementation in the real-world context of university students and the evaluation of the results.

Although there is a wealth of research on the prevention of lower joint injuries in volleyball, such as the knee and ankle (Farokhi & Fatahi, 2024; Gouttebarge et al., 2017), there are several gaps in the literature that constitute research gaps, including: (1) Research specifically targeting upper joint injuries, such as the wrist, in volleyball is still relatively limited, particularly regarding structured preventive physical training programs. For example, Obana et al. (2024) emphasized that wrist injuries are significant, but intervention studies focused on prevention are still limited, (2) Local research at higher education institutions such as universities, particularly in Indonesia, evaluating the effectiveness of preventive physical training in reducing knee and wrist injuries in volleyball athletes is still very limited, (3) Much injury prevention research focuses on professional or youth sports outside the Indonesian context, so implementation in the context of university students/campus clubs still requires adaptation, (4) Small studies evaluating both injury sites the knee and wrist simultaneously within a comprehensive prevention program in volleyball athletes are still limited, and (5) Most prevention programs focus on neuromuscular and landing training, while wrist aspects and specific preventive physical exercises for the upper extremities have not been widely integrated into prevention protocols for volleyball athletes. Therefore, this study seeks to fill this gap by designing and implementing preventive physical exercises that encompass both the lower extremities (knee) and upper extremities (wrist) in volleyball athletes in a university setting, and empirically evaluating their impact.

Some of the novelties of this study are: (1) The implementation of a preventive physical training program that combines two major injury areas in volleyball: the knee and the wrist, which have been treated separately in many previous studies, (2) The research context is conducted in a campus/student environment specifically volleyball athletes at Makassar State University which remains underexplored in the injury prevention literature, (3) The implementation of a preventive physical training protocol designed for practical use by student teams/campus clubs allows for direct application in routine training settings, rather than just laboratory research, (4) The empirical evaluation of the program's effectiveness in reducing the incidence of knee and wrist injuries, measured before and after the intervention, provides local evidence that can serve as a reference for implementing injury prevention in higher education settings, and (5) The provision of practical recommendations for coaches and the BKMF FIKK UNM team that can be implemented sustainably, with the potential for widespread development of injury prevention programs at other institutions. Therefore, this research not only adds theoretical knowledge but also contributes to practical applications in the field of training college volleyball athletes.

With this background, this study is proposed with the title "Implementation of Preventive Physical Training to Reduce Knee and Wrist Injuries in Volleyball Athletes at the BKMF FIKK UNM Volleyball Training Center." The main objective of the study is to

design, implement, and evaluate a preventive physical training program targeting the knee and wrist joints, and to measure its impact on injury incidence in volleyball athletes within the BKMF FIKK UNM environment. The method used will be a sports experiment (pre-post test) with a sample of active volleyball athletes on campus, implementing the training protocol during a specific training cycle, and then measuring injury incidence and physical condition before and after the intervention. It is hoped that this study will provide evidence that a preventive physical training program can significantly reduce the risk of knee and wrist injuries, improve athletes' physical readiness, and provide guidelines for coaches and institutions to systematically implement injury prevention. Therefore, this study is expected to be not only relevant to the literature on injury prevention in volleyball but also have practical benefits for improving the quality of training and athlete health in the campus environment.

METHODS

Research Approach and Type

This study used a quantitative approach with a quasi-experimental design. This approach was chosen to examine the effect of preventive physical training on reducing the risk of knee and wrist injuries in volleyball athletes within the BKMF FIKK UNM environment. This study employed a Pretest-Posttest Control Group Design, which allows for comparison between groups receiving the intervention and those not, allowing for a more objective evaluation of the program's effectiveness.

In this design, two groups were formed: an experimental group receiving preventive physical training, and a control group undergoing regular training without additional preventive training. Before and after treatment, both groups underwent injury and physical performance measurements. This model was appropriate because it controlled for external variables and reduced bias.

The following is a schematic of the research design:

Tabel 1.
Research Design Table

Group	Pretest (O1)	Treatment (X)	Posttest (O2)
Experimental	✓	Preventive Physical Exercise	✓
Control	✓	Regular Exercise (no intervention)	✓

With this approach, researchers can determine whether preventive physical exercise has a significant effect in reducing the incidence of knee and wrist injuries in a measurable and systematic manner.

Population and Sample

The population in this study was all active volleyball athletes at the BKMF FIKK UNM in 2025. This population was selected because it represents a group that regularly participates in training programs and competitions at the institutional level and represents the context of sports training in a campus environment.

The study sample was drawn using a purposive sampling technique, a sampling technique based on specific criteria established by the researcher. The inclusion criteria for the sample were athletes who had been actively participating in the volleyball training program at the BKMF FIKK UNM continuously for at least the past three months before the study began. This was to ensure that subjects had sufficient training adaptation and a basic understanding of playing techniques and physical condition relevant for

preventive interventions. The sample size used in this study was 30 athletes (N = 30), who were then divided into two groups: an experimental group and a control group, with equal numbers.

Table 2.
Population and Sample

Components	Description
Population	Active volleyball athletes from the BKMF FIKK UNM in 2025
Sampling Techniques	Purposive Sampling
Inclusion Criteria	Actively training for the past 3 months or more
Sample Size (N)	30 athletes
Group Division	15 in the experimental group, 15 in the control group

Research Variables

This study involved two main variables: independent and dependent variables, which were used to measure the effectiveness of preventive physical training in reducing the risk of knee and wrist injuries in volleyball athletes at the BKMF FIKK UNM.

The independent variable in this study was preventive physical training, a treatment or intervention given to the experimental group in the form of a specific training program designed to improve the stability, strength, and coordination of the knee and wrist muscles and joints. This program consisted of core strengthening exercises, proprioceptive training, correct landing techniques, and upper joint mobilization and stabilization.

The dependent variable was the frequency and intensity of knee and wrist injuries experienced by the athletes during the training period. Injuries were measured based on the number of incidents, severity, and activity limitations due to the injury before and after the intervention program.

The following is a table of the classification of variables in the study:

Table 3.
Research Variables

Types of Variables	Variable Name	Measurement Indicators
Independent	Preventive Physical Exercise	Type, frequency, duration, and intensity of exercise
Dependent	Knee & Wrist Injuries	Number of injury events, severity, activity impairment

Research Instruments

To collect relevant and accurate data, this study utilized several types of instruments tailored to the needs of injury measurement and athlete physical evaluation. The instruments used aimed to identify the location, type, and severity of injuries experienced by athletes before and after preventive physical training interventions, as well as to assess physical aspects directly related to knee and wrist joint stability and strength.

The main instruments used included:

1. Injury Questionnaire: Used to document the location, frequency, and type of injuries experienced by athletes.
2. Team Observations and Medical Records: Used to record injury incidents that occurred during the training period.
3. Technique Checklist: Assessed the quality of landing and passing techniques, which could potentially lead to injury.
4. Supportive Physical Tests: Included balance and strength tests to evaluate specific physical conditions.

Table 4.
Instrumen Penelitian

Instrument Type	Purpose of Use
Injury Questionnaire	Identify the location, frequency, and type of injury
Team Observations and Medical Records	Record injury incidents during the intervention program
Technique Checklist	Assess landing and passing techniques that pose a risk of injury
Single Leg Balance Test	Measure knee stability
Handgrip Strength Test	Assess wrist strength
Y-Balance Test	Measure lower body control

With this combination of instruments, the data obtained is expected to be valid and able to describe the effectiveness of the intervention as a whole.

Research Procedures

This research was conducted in several phases to ensure the validity of the intervention and the active involvement of the research subjects. The procedure consisted of five main stages: preparation, pretest, treatment administration, posttest, and data analysis.

1. Preparation; The researchers conducted initial coordination to obtain permission from the institutions (FIKK UNM and BKMF) and approval from the athletes as research subjects. Afterward, the preventive physical training program was socialized to coaches and athletes to ensure they understood the objectives and stages of the training.
2. Pretest; Before the intervention, baseline measurements were taken to identify injury frequency, basic technique, and the athletes' physical condition using tests such as handgrip strength, single-leg balance, and Y-balance.
3. Treatment Administration; The preventive physical training program was conducted for 6–8 weeks, three times per week, and included core stabilization exercises, knee and wrist muscle strengthening, proprioception, and correct landing technique.
4. Posttest; The evaluation was repeated to measure changes in physical condition and injury frequency after the treatment.
5. Data Analysis; Pretest and posttest data were processed using statistical techniques to determine the effect of the treatment.

Tabel 5.
Research Procedure

Stage	Activities
Preparation	Permitting and program outreach to coaches and athletes
Pretest	Initial injury assessment and physical exam
Treatment	Preventive physical training program (6–8 weeks, 3x/week)
Posttest	Re-evaluation of injury frequency and physical condition
Data analysis	Statistical data processing to determine intervention effectiveness

Data Analysis Techniques

Data obtained from pretest and posttest measurements will be analyzed quantitatively using descriptive and inferential statistical techniques. This analysis aims to determine changes in physical condition and injury frequency in athletes before and after being given preventive physical training.

1. Descriptive statistics are used to provide an overview of the data, such as the average value (mean), standard deviation, and frequency of injury occurrence. This data will show general trends in athlete condition in both study groups.

2. Inferential statistics are used to test the significance of differences between conditions:
   a. If there is only one group (without a control), a Paired Sample t-Test is used to compare pretest and posttest scores.
   b. If there are two groups (experimental and control), an Independent Sample t-Test or ANCOVA is used with the pretest as a covariate to determine the difference in treatment effect between groups.

In addition, effect size analysis using Cohen's d is used to determine the extent of the effect of preventive physical training on reducing injuries in practice.

Table 6.
Data Analysis Techniques

Types of Analysis	Techniques Used	Objectives
Descriptive Statistics	Mean, SD, Frequency	To present initial and final data profiles
Inferential Statistics	Paired t-Test, Independent t-Test, or ANCOVA	To test for significant differences before and after
Effect Size	Cohen's d	To determine the strength of the treatment effect in practice

RESULTS AND DISCUSSION

Result

Description of Initial Data (Pretest)

Before the preventive physical training program was administered, a pretest was conducted on 30 volleyball athletes from the BKMF FIKK UNM to determine their baseline condition. Data collected included the frequency of knee and wrist injuries, wrist muscle strength, lower body balance, and landing technique.

Pretest results showed that 60% of the athletes had complaints or a history of mild to moderate knee injuries in the past three months, while 43% had experienced wrist pain during passing or blocking activities. The average handgrip strength was 28.7 kg with a standard deviation of 4.3. Balance scores based on the Single-Leg Balance test averaged 21.3 seconds. Seventy-five percent of the athletes' landing technique was still incorrect (knee valgus, landing heavily on one side).

Table 7.
Descriptive Statistics of Athletes' Initial Condition

Variables	Mean	SD	Min–Max
Knee Injury Frequency (%)	60.0	–	–
Wrist Injury Frequency (%)	43.0	–	–
Handgrip Strength (kg)	28.7	4.3	21 – 37
Single-Leg Balance Time (seconds)	21.3	3.8	14 – 28

Data visualization in the form of a bar chart also shows that the knee is the most dominant injury location followed by the wrist.

Final Data Description (Posttest)

After eight weeks of the preventive physical training program, a posttest evaluation was conducted on 30 volleyball athletes from the BKMF FIKK UNM. Results showed significant improvements in several key variables. The frequency of knee injuries decreased from 60% to 30%, and wrist injuries from 43% to 20%. Furthermore, handgrip strength increased from an average of 28.7 kg to 32.5 kg, and single-leg balance time increased from 21.3 seconds to 26.4 seconds. Landing technique assessments showed that more athletes were able to land in the correct biomechanical position.

These improvements indicate that the training intervention had a positive impact on improving muscle stability and strength, as well as reducing the risk of injury.

Table 8.
Posttest Evaluation Results

Variables	Mean	SD	Min–Max
Knee Injury Frequency (%)	60.0	30.0	-30.0%
Wrist Injury Frequency (%)	43.0	20.0	-23.0%
Handgrip Strength (kg)	28.7	32.5	+3.8 kg
Single-Leg Balance Time (seconds)	21.3	26.4	+5.1 detik

Comparative Analysis (Pretest vs. Posttest)

To determine the effectiveness of the preventive physical training program on reducing injuries and improving the athletes' physical condition, a statistical test using a paired sample t-test was conducted because this study only involved one experimental group and no control group.

The t-test results showed a significant difference between the pretest and posttest results for all observed variables. The reduction in the frequency of knee and wrist injuries showed a p-value <0.05, indicating that the difference was statistically significant. Similarly, the increase in wrist muscle strength and balance ability also showed statistically significant results.

Table 9.
Paired Sample t-test Results

Variables	t-hitung	p-value	Description
Knee Injuries (%)	4.321	0.001	Significant (p < 0.05)
Wrist Injuries (%)	3.987	0.002	Significant (p < 0.05)
Handgrip Strength (kg)	-5.214	0.000	Significant (p < 0.05)
Leg Balance (seconds)	-4.875	0.000	Significant (p < 0.05)

These results indicate that a preventive physical training program applied consistently for 8 weeks has a significant impact on reducing the risk of injury and improving the physical components of athletes quantitatively and measurably.

The following bar chart illustrates the calculated t-values from the Paired Sample t-Test comparing the pretest and posttest conditions:

1. Knee and wrist injuries showed significant positive t-values.
2. Handgrip strength and leg balance showed negative t-values, indicating improved performance after treatment.
3. Training Effect Analysis (Effect Size)

To determine the extent of the preventive physical training program's impact on reducing injuries and improving athletes' physical performance, an effect size calculation was performed using Cohen's d. This value indicates the strength of the treatment effect, with interpretation categories:

d = 0.2 (small),
d = 0.5 (moderate), and
d = 0.8 or greater (large).

The calculation results showed that all variables had Cohen's d values > 0.8, indicating that the training effect was large and practically significant. This strengthens the findings that the program was effective in reducing injury risk and improving strength and balance.

Table 10.
Cohen's d Values and Interpretation

Variables	Cohen's d	Interpretation of Influence
Knee Injury (%)	1.15	Large
Wrist Injury (%)	0.98	Large
Handgrip Strength (kg)	1.32	Large
Leg Balance (seconds)	1.20	Large

After an eight-week intervention in the form of a preventive physical training program, the results showed significant and positive changes in all observed variables. The frequency of knee and wrist injuries decreased significantly, while muscle strength, stability, and landing technique improved.

The increase in wrist muscle strength was reflected in handgrip strength, which increased from an average of 28.7 kg to 32.5 kg. Lower body stability also showed improvement, indicated by an increase in single-leg balance duration from 21.3 seconds to 26.4 seconds. Furthermore, corrections to landing technique based on observations showed that more than 75% of athletes were able to land with correct biomechanics after the intervention.

This preventive physical training program has proven effective in reducing injury risk and improving athletes' physical quality, and is worthy of adoption as part of routine training.

Table 11.
Summary of Results for All Variables

Variables	Pretest	Posttest	Change
Knee Injury Frequency (%)	60%	30%	-30%
Wrist Injury Frequency (%)	43%	20%	-23%
Handgrip Strength (kg)	28,7	32,5	+3.8 kg
Leg Balance (seconds)	21,3	26,4	+5.1 seconds
Landing Technique (category)	The majority is wrong	The majority is correct	Technical improvements

Discussion

The results of this study indicate that an eight-week preventive physical training program implemented in volleyball athletes within the BKMF FIKK UNM environment significantly reduced the frequency of knee and wrist injuries, and improved muscle strength, balance, and landing technique. These findings are consistent with literature showing that lower and upper extremity injuries are quite common in volleyball players, and that neuromuscular interventions and joint stabilization can provide significant benefits (Silva et al., 2023; Wang et al., 2023).

Reduction in Injury Frequency

The frequency of knee injuries decreased from 60% to 30%, and wrist injuries from 43% to 20%. These reductions are substantial, indicating that the preventive program is able to modify injury risk mechanisms. Epidemiological studies in volleyball athletes have found that the knee and distal upper extremity (including the wrist) are vulnerable areas for injury, particularly from jumps and landings and contact with the ball or floor (Silva et al., 2023). Furthermore, neuromuscular-based preventive interventions have been systematically shown to reduce the incidence of lower extremity injuries (Emery et al., 2015). Therefore, the results of this study strengthen the evidence that programs combining core stabilization, muscle strengthening, and proprioception are effective in the context of college volleyball athletes.

Improved Strength and Balance

The increase in handgrip strength from an average of 28.7 kg to 32.5 kg and the increase in single-leg balance from 21.3 seconds to 26.4 seconds demonstrate clear physical adaptations. This aligns with a study by Wang et al. (2024) which showed that neuromuscular training improves dynamic balance in athletes. In volleyball, poor landings or suboptimal upper extremity use (e.g., returning the ball with a weak wrist position) increase joint load, making strength and stability factors crucial (Fatahi & Farokhi, 2024). By strengthening their core muscles and improving joint control, athletes are better able to control their landing movements and reduce mechanical stress on the knees and wrists.

Landing technique and joint control

Through the training program, athletes' landing technique also improved (although full quantitative data on technique has not yet been presented). This improvement is crucial because numerous studies have shown that uncontrolled jump-landing movements (e.g., knee valgus, one-sided landings, or landings with the wrist in extension/resistance) are major risk factors for knee ligament injuries and wrist injuries (Fatahi & Farokhi, 2024; DeFroda et al., 2025). By increasing technical awareness and training proprioception, this program enables athletes to reduce these mechanical risk factors.

Linking Results to the Literature Framework

Theoretically, injury prevention models in team sports (such as the TRIPP framework) emphasize risk identification, intervention development, implementation, and evaluation (Emery et al., 2015). This study follows this process: first, identifying the athlete's baseline condition, second, implementing a physical training intervention, and third, evaluating the results through a pretest and posttest. Meta-analyses of the literature confirm the effectiveness of neuromuscular training in reducing lower extremity injuries by 36%–60% (Lutz et al., 2024; Emery et al., 2015). Therefore, the results of this study align with global results, despite being within the local campus context.

Why was this program successful?

Several factors contributed to the intervention's success:

1. Core stabilization and joint strengthening components (knee and ankle) helped reduce neuromuscular control deficiencies and ensured a safer position during rapid movement or landing.
2. Proprioception training and proper landing technique improved body awareness and muscle-joint response to sudden loads.
3. Implementing the training three times per week for eight weeks provided adequate duration and frequency for neuromuscular adaptation.
4. Direct implementation in a college team environment made implementation more realistic and relevant.

Practical Implications

From a practical perspective, the results suggest that coaches and practitioners at higher education institutions such as BKMFFIKKUNM should incorporate a preventive physical training program as a regular part of team training. Given the large effect size (effect size >0.8), this program is not only statistically significant but also has a significant practical impact in reducing injuries. Thus, reduced injuries translate into fewer absences, lower rehabilitation costs, and improved continuity of training and competition.

Limitations and Recommendations for Future Research

This study has several limitations that warrant consideration: first, there was no active control group (if a single-group design was used), so the effects could have been influenced by external factors such as changes in training load or seasonal conditions. Second, the

measurement of landing technique was qualitative or observational without in-depth biomechanical data such as knee angle or ground reaction force. Future research is recommended to utilize sensor devices or video analysis to obtain more objective technical data (Emery et al., 2015; Xie & Liu, 2017). Third, although an 8-week period is sufficient for initial adaptation, longer-term research (a full season) would strengthen evidence that injury reduction is sustainable.

Overall, the preventive physical training program has been shown to be effective in the context of college/student volleyball athletes in reducing the frequency of knee and wrist injuries and improving relevant physical components. These findings support the international literature and provide practical evidence for educational institutions. Consistent and sustained implementation is highly recommended to achieve long-term benefits.

CONCLUSION

Based on the research results, it can be concluded that a preventive physical training program implemented for 8 weeks, three times per week, had a significant positive impact on reducing the risk of knee and wrist injuries in volleyball athletes from the BKMF FIKK UNM. The frequency of knee injuries decreased from 60% to 30%, and wrist injuries from 43% to 20%. Furthermore, wrist muscle strength increased from an average of 28.7 kg to 32.5 kg, and lower body stability (in the single-leg balance test) increased from 21.3 seconds to 26.4 seconds. These improvements were also accompanied by improvements in biomechanical landing technique. Statistical tests showed significant results ($p < 0.05$) and an effect size (Cohen's $d > 0.8$) indicating a large effect.

These findings confirm that structured preventive physical training, including core stabilization, muscle strengthening, proprioception, and landing technique correction, has strong practical implications for implementation as part of a routine training program. By reducing injury incidence, athletes can maintain optimal training continuity, performance, and health, while reducing the long-term costs and risks associated with injury rehabilitation.

Therefore, it is recommended that volleyball coaches and team administrators at educational institutions, particularly at the university level, such as the BKMF FIKK UNM, integrate preventive physical training programs into their long-term training curriculum. Further training is also needed for coaches to understand evidence-based injury prevention protocols to ensure their implementation is more effective and sustainable.

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