Original Research

The Effectiveness of Trunk and Balance Warm-up Exercises in Prevention, Severity, and Length of Limitation From Overuse and Acute Lower Limb Injuries in Male Volleyball Players

Yuki Muramoto1 a, Hironobu Kuruma2
1 Institute for Integrated Sports Medicine, Keio University, 2 Department of Physical Therapy Science, Tokyo Metropolitan University Graduate School of Human Health Sciences

Keywords: men's volleyball, exercise-based warm-up, injury burden, overuse, acute injury

https://doi.org/10.26603/001c.38019

Background

Injuries in volleyball players are most common in the ankles and knees. Many volleyball players suffer from overuse injuries because of the strain placed on the lower extremities from repeated jumping. A characteristic of players who are most at risk for lower extremity injuries is the tendency to display trunk instability during landing, such as lateral flexion and rotation. Research has shown the effectiveness of exercise-based warm-up interventions for acute volleyball injuries. However, comprehensive analyses on the use of lower extremity, trunk, and balance programs to prevent overuse injuries are lacking.

Purpose

To examine the effects of trunk and balance warm-up exercises on the prevention, severity, and length of limitation of overuse and acute lower limb injuries in male volleyball players.

Study Design

Prospective, single-cohort study.

Methods

This study involved the 2019 (control group) and 2021 (intervention group) male volleyball teams. The control and intervention groups were on the same team; however, seven players joined in 2021 through a sports referral program through which different players are recruited. Measurements included injury incidence rate, injury severity, and injury burden. The intervention involved the addition of trunk and balance exercises during the 2021 season.

Results

There was no significant difference in injury incidence rates between groups. Injury severity decreased by 5.7 days for overuse injuries (p=0.04). Injury burden decreased by 11.8 (days/1000 player hours) overall and by 7.1 (days/1000 player hours) for overuse injuries.

Conclusion

The results show that an exercise-based warm-up aimed at improving trunk posture during landing did not reduce the incidence rate of injury in men's volleyball. However, the addition of this warm-up did significantly reduce the severity of overuse injury.

a Corresponding author:
Muramoto Yuki
35 Shinanomachi, Shinjuku-ku, Tokyo
Institute for Integrated Sports Medicine, School of Medicine, Keio University
yukimuramoto1019@gmail.com

International Journal of Sports Physical Therapy
Level of Evidence

INTRODUCTION

Ankle and knee injuries are among the most common injuries in volleyball players. Jumper’s knee, in particular, accounts for approximately 40% of all lower extremity injuries in these athletes. Many volleyball players develop overuse injuries, such as jumper’s knee, due to the strain placed on the lower extremities with repeated jumping. Additionally, volleyball players have been reported to suffer from lower extremity injuries due to environmental factors, such as the long duration of practice (12 hours/week), the number of jumps, and the material of the gymnasium floor (hard surface) upon which they train and play. Furthermore, physical factors, such as decreased quadriceps muscle strength, jump height, and landing ability may contribute to injuries.

Previous research indicates that lower limb injuries are more likely to occur with an unstable landing motion. De Bleecker et al. examined the landing movements of athletes with lower limb injuries, and several associations with trunk movement were reported. An examination of movements occurring in the thoracic spine, hip, knee, and ankle joints during the drop jump landing from a 30-cm platform, found that a group with medial tibial stress syndrome exhibited significant compensation in the thoracic spine, hip, and ankle joints during landing. These reports suggest that athletes with lower extremity injuries may have greater trunk instability (poorer trunk control) during landing.

In recent years, it has been suggested that a comprehensive exercise-based warm-up that includes lower extremity, trunk, and balance training prior to practice may reduce the incidence of acute injuries, such as those to the anterior cruciate ligament. However, the effect of comprehensive exercise-based warm-up on overuse injuries, such as lower extremity injuries in volleyball players, has not been demonstrated. Overuse injuries are common among athletes with high practice and competition loads. Consequently, the concept of injury burden has been used to evaluate overuse. Greater losses in playing time indicate a lower team performance. Reduction of incidence and burden of overuse injury is important to team outcomes and performance.

Therefore, the purpose of this study was to examine the effects of trunk and balance warm-up exercises on the prevention, severity, and length of limitation of overuse and acute lower limb injuries in male volleyball players.

METHODS

PARTICIPANTS

Men’s volleyball teams from the first division of a University Federation were included in this study with participants from the 2019 team as the control group and the team from 2021 as the intervention group. The control and intervention groups were on the same team; however, seven players joined through a sports referral program in which different players are recruited (4 outsides, 2 middles, 1 libero). The two groups had the same practice (including training) and match hours (Control: practice=744, match=142, Intervention: practice=687, match=200). This study was approved by the Ethics Committee of the affiliated Hospital. The objectives of this study were explained to the participants in oral and written forms, and their written consent to participate in the study was obtained. The obtained data were de-identified.

SURVEY PERIOD

The study was conducted during the 2019 (January–December 2019) and 2021 (January–December 2021) seasons. Throughout both seasons, the number of days of practices and competitions, participating players, and occurrence of lower extremity injuries were recorded by the athletic trainers affiliated with the teams.

INJURY DEFINITION

After an injury, trainers were asked to classify whether it was an acute (associated with a specific, clearly identifiable traumatic event) or overuse (no specific identifiable event responsible for its occurrence) injury. Furthermore, trainers were required to register the affected anatomical area.

CALCULATION OF INJURY INCIDENCE, SEVERITY, AND BURDEN

The incidence of lower extremity injury incidence was calculated by dividing the number of incidents by the number of potential exposure times (i.e., practice and matches) and multiplying this value by 1000. Using this formula, an incidence rate was obtained relative to 1000 player hours. Severity was defined as the number of days from injury to return to play. Cumulative time loss was categorized as: slight (0 days), mild (1–7 days), moderate (8–28 days), or severe (>28 days). Return to competition was defined as the day when the athlete fully participated in all practices or was able to participate in competitions.

Injury burden was defined as the measure of time lost from competition due to injury and was calculated as the product of the incidence rate and average severity of the injury.

INTERVENTION METHOD

Prior to the 2019 season, warm-up consisted of three lower extremity exercises (hip circles, reverse Nordic curls, and overhead deadlifts), jogging, stretching, and agility drills for 20 min daily. In the 2021 season, the author added new core and balance exercises. The intervention exercises consisted of three core (abdominal bracing, side plank with hip side raise, and side plank with trunk rotation) and Y-Bal...
Table 1. Physical characteristics of the participants and practice game durations

|                          | Control (n=17) | Intervention (n=17) | P  |
|--------------------------|---------------|---------------------|----|
| Age (years)              | 20.82±0.95    | 21.06±0.83          | 0.44|
| Height (cm)              | 184.56±7.66   | 183.81±10.48        | 0.81|
| Mass (kg)                | 75.44±9.06    | 75.61±8.94          | 0.95|

**RESULTS**

The results of this study indicate that comprehensive exercise-based warm-up programs did not reduce acute and overuse injury rates. The number of incidents of injury in the control group was 22, while the number of incidents in the intervention group was 16. The team injury rates in this study were 3.4 and 3.1 days/1000 player hours. Compared to the results of a previous study, which showed a range of 3.6–10.52 days/1000 player hours for professional volleyball teams and players in the World League, the injury rate in this study was low. To prevent overuse, it is necessary to manage the workload, including the amount of practice and the number of games played. The total number of practice hours and the number of games played in both groups were 896 and 887, respectively. The total hours of practice and number of games did not change between the control and intervention groups, and therefore, a likely reason that the incidence rate did not change.

**DISCUSSION**

The number of incidents of injury in the control group was 22 (overuse: 12; acute:10), while the number of incidents in the intervention group was 16 (overuse 12; acute four). No significant difference in overuse or acute injury incidence was observed. The severity of injuries among the control group was eight minor, 11 mild, two moderate, and one major. The severity of injuries among the intervention group was 15 minor, one moderate, and two major. The severity of overuse injury was lower in the intervention group than that of the control group (mean difference: 2.82, 95% CI: 0.17–5.47, Cohen’s d: 0.59, p=0.04). Injury burden decreased by 11.8 days/1000 player hours overall, 7.1 days/1000 player hours for overuse injuries, and 4.7 days/1000 player hours for acute injury in the intervention group compared to the control group.

**Statistical Methods**

Injury incidence between teams was examined using the χ² square test. The severity of injuries was compared between groups using an unpaired t-test. All data were analyzed using SPSS software (version 22.0, IBM Corporation, Japan) with a priori alpha level of 0.05.

**Results**

Table 1 presents the information regarding the two groups. The control group (n=17, Age=20.82±0.95 years, Height=184.56±7.66 cm, Mass=75.44±9.06 kg) and the intervention group (n=17, Age=21.06±0.95 years, Height=183.81±10.48 cm, Mass=75.61±8.94 kg). There were no significant differences in age, height, or mass between the control and intervention groups (Table 1).

The number of incidents of injury in the control group was 22 (overuse: 12; acute:10), while the number of incidents in the intervention group was 16 (overuse 12; acute four). No significant difference in overuse or acute injury incidence was observed (Table 2). The severity of injuries among the control group was eight minor, 11 mild, two moderate, and one major. The severity of injuries among the intervention group was 15 minor, one moderate, and two major. The severity of overuse injury was lower in the intervention group than that of the control group (mean difference: 2.82, 95% CI: 0.17–5.47, Cohen’s d: 0.59, p=0.04). Injury burden decreased by 11.8 days/1000 player hours overall, 7.1 days/1000 player hours for overuse injuries, and 4.7 days/1000 player hours for acute injury in the intervention group compared to the control group.

**Discussion**

The results of this study indicate that comprehensive exercise-based warm-up programs did not reduce acute and overuse injury rates. The number of incidents of injury in the control group was 22, while the number of incidents in the intervention group was 16. The team injury rates in this study were 3.4 and 3.1 days/1000 player hours. Compared to the results of a previous study, which showed a range of 3.6–10.52 days/1000 player hours for professional volleyball teams and players in the World League, the injury rate in this study was low. To prevent overuse, it is necessary to manage the workload, including the amount of practice and the number of games played. The total number of practice hours and the number of games played in both groups were 896 and 887, respectively. The total hours of practice and number of games did not change between the control and intervention groups, and therefore, a likely reason that the incidence rate did not change.

Chronic injury severity may be reduced with the addition of an exercise-based warm-up program. In 2019, chronic injury severity was on average 5.75 days, and in 2021, it was zero days. Chronic injury severity has been reported as 2.9 days in professional female volleyball players and 4.2 days in amateur-level players. Professional players may have lower injury severity due to better management of conditions. In 2021, the authors hypothesized that the players may have finished the season without missing a practice session by providing an appropriate workload during the season, just like professional players.

The results of this study show that the exercise-based warm up program was able to reduce overall injury burden by 11.8 days/1000 players hours and the injury burden of chronic injuries by 7.1 days/1000 players hours. In this case, the comprehensive loading, including lower extremity exercises as well as trunk exercises, and trunk control, may have allowed athletes with overuse pain to maintain the muscle strength required to participate in practice.

Fuller was able to reduce the number of missed days by four and the overall injury burden by 26%, improving the performance of a rugby team. In the current study, the injury burden decreased by 7.1 days for overuse cases and 4.7 days for acute injury cases. Therefore, the overall injury burden was reduced by 58% (11.8 days) compared to controls. The exercise-based warm-up performed in the cur-
Three exercises were performed in 2019 for A. The additional exercises in 2021 included those shown in B and C. For all exercises, the figure on the left demonstrates the starting position, and the figure on the right demonstrates the ending position.

A: Conventional exercises: 1=hip circle, 2= reverse Nordic curl, 3= overhead deadlifts; 10reps*3sets
B: Trunk exercise: 1= abdominal bracing, 2= side plank with hip side raise, and 3= side plank with trunk rotation; 30seconds*3sets
C: Y-Balance exercise: 1= side reach, 2= posterior-medial reach, and 3= front reach; 10reps*3sets
Table 2. Comparison of severity and injury burden between the control and intervention group

|                  | Control | Intervention | p-value | 95%CI   |
|------------------|---------|--------------|---------|---------|
| **Overuse**      |         |              |         |         |
| Injury incidence (/1000AEh) | 1.9     | 2.3          | 0.85    | -0.8, 0 |
| Severity (time loss days) | 3.7     | 0*           | 0.03    | 0.2, 5.5|
| Injury burden (time loss days/1000AEh) | 7.1     | 0            | -       | 0.1, 14.0|
| **Acute**        |         |              |         |         |
| Injury incidence (/1000AEh) | 1.6     | 0.8          | 0.77    | -0.1, 1.6|
| Severity (time loss days) | 13.3    | 21.3         | 0.81    | -15.9, 0|
| Injury burden (time loss days/1000AEh) | 21.1    | 16.4         | -       | 0.1, 9.4|

* The severity of overuse injury was lower in the intervention group than that of the control group (p< 0.05)

The current study may have been effective in reducing the number of practice days lost due to acute and chronic injuries due to the varied components of the program.

There are some limitations to the present study. The results of this study are based on an intervention conducted on a single team of men. Lower extremity injuries are also common in female volleyball players. In addition, female players are more prone to landing movements that can cause lower limb injuries.23,25 In the future, it would be beneficial to introduce this intervention to female volleyball teams to determine has a similar effect on injury burden.

Furthermore, the results of this study do not allow any assessment of the relationship between landing motion (related to the trunk and balance interventions) and lower limb injuries because no biomechanics were assessed. In the future, the authors intend to examine whether a comprehensive warm up that includes core and balance exercises would improve landing mechanics.

CONCLUSION

The results of the present study indicate that the a program of trunk and balance warm-up exercises did not reduce the incidence rate of overuse injury in male volleyball players, however, it did reduce the severity injuries, of both overuse and acute mechanisms.

CONFLICTS OF INTEREST

The authors have no COI's to disclose.

ACKNOWLEDGMENTS

The authors thank all those who participated in the research and the athletic trainer who managed the injuries of the team members.

Submitted: February 20, 2022 CDT, Accepted: June 10, 2022 CDT

This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CCBY-NC-4.0). View this license’s legal deed at https://creativecommons.org/licenses/by-nc/4.0 and legal code at https://creativecommons.org/licenses/by-nc/4.0/legalcode for more information.
REFERENCES

1. Kilic O, Maas M, Verhagen E, Zwerver J, Gouttebarge V. Incidence, aetiology and prevention of musculoskeletal injuries in volleyball: A systematic review of the literature. Eur J Sport Sci. 2017;17(6):765-793. doi:10.1080/17461391.2017.1306114

2. Zwerver J, Bredeweg SW, Van Den Akker-Scheek I. Prevalence of Jumper’s Knee Among Nonelite Athletes From Different Sports. Am J Sports Med. 2011;39(9):1984-1988. doi:10.1177/0363546511413370

3. Reeser JC. Strategies for the prevention of volleyball related injuries. Br J Sports Med. 2006;40(7):594-600. doi:10.1136/bjsm.2005.018234

4. Tsai YJ, Chia CC, Lee PY, Lin LC, Kuo YL. Landing kinematics, sports performance, and isokinetic strength in adolescent male volleyball athletes: Influence of core training. J Sport Rehabil. 2019;29(1):65-72. doi:10.1123/jsr.2018-0015

5. De Bleecker C, Vermeulen S, De Blaïser C, Willems T, De Ridder R, Roosen P. Relationship between jump-landing kinematics and lower extremity overuse injuries in physically active populations: A systematic review and meta-analysis. Sports Med. 2020;50(8):1515-1532. doi:10.1007/s40279-020-01296-7

6. Cannon J, Cambridge EDJ, McGill SM. Anterior cruciate ligament injury mechanisms and the kinetic chain linkage: The effect of proximal joint stiffness on distal knee control during bilateral landings. J Orthop Sports Phys Ther. 2019;49(8):601-610. doi:10.2519/jospt.2019.8248

7. Chimera NJ, Warren M. Use of clinical movement screening tests to predict injury in sport. World J Orthop. 2016;7(4):202-217. doi:10.5312/wjo.v7.i4.202

8. Verrelst R, De Clercq D, Willems TM, Roosen P, Witvrouw E. Contralateral risk factors associated with exertional medial tibial pain in women. Med Sci Sports Exerc. 2014;46(8):1546-1553. doi:10.1249/ms s.0000000000000280

9. Verrelst R, De Clercq D, Vanreuterghem J, Willems T, Palmans T, Witvrouw E. The role of proximal dynamic joint stability in the development of exertional medial tibial pain: a prospective study. Br J Sports Med. 2014;48(5):388-395. doi:10.1136/bjsports-2012-092126

10. Gouttebarge V, Barboza SD, Zwerver J, Verhagen E. Preventing injuries among recreational adult volleyball players: Results of a prospective randomised controlled trial. J Sports Sci. 2020;38(6):612-618. doi:10.1080/02640414.2020.1721255

11. Timoteo TF, Deben PB, Miloski B, Werneck FZ, Gabbett T, Bara Filho MG. Influence of workload and recovery on injuries. J Strength Cond Res. 2021;35(3):791-796. doi:10.1519/jsc.0000000000002754

12. Soligard T, Schwellnus M, Alonso JM, et al. How much is too much? (Part 1) International Olympic Committee consensus statement on load in sport and risk of injury. Br J Sports Med. 2016;50(17):1030-1041. doi:10.1136/bjsports-2016-096381

13. Clarsen B, Myklebust G, Bahr R. Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology: the Oslo Sports Trauma Research Centre (OSTRC) Overuse Injury Questionnaire. Br J Sports Med. 2013;47(8):495-502. doi:10.1136/bjsports-2012-091524

14. Asheim C, Stavenes H, Andersson SH, Engbretsen L, Clarsen B. Prevalence and burden of overuse injuries in elite junior handball. BMJ Open Sport Exerc Med. 2018;4:e000591.

15. West SW, Williams S, Kemp SPT, Eager R, Cross MJ, Stokes KA. Training load, injury burden, and team success in professional rugby union: Risk versus reward. J Athl Train. 2020;55(9):960-966. doi:10.4085/1062-6050-0387.19

16. Fuller CW. Injury risk (burden), risk matrices and risk contours in team sports: A review of principles, practices and problems. Sports Med. 2018;48(7):1597-1606. doi:10.1007/s40279-018-0915-5

17. Nordstrøm A, Bahr R, Talsnes O, Clarsen B. Prevalence and burden of health problems in male elite ice hockey players: A prospective study in the Norwegian Professional League. Orthop J Sports Med. 2020;8(2):232596712090240. doi:10.1177/232596712090240

18. Sasaki S, Tsuda E, Yamamoto Y, et al. Core-muscle training and neuromuscular control of the lower limb and trunk. J Athl Train. 2019;54(9):959-969. doi:10.4085/1062-6050-113-17
19. Root H, Trojan T, Martinez J, Kraemer W, DiStefano LJ. Landing Technique and performance in youth athletes after a single injury-prevention program session. *J Athl Train*. 2015;50(11):1149-1157. doi:10.4085/1062-6050-50.11.01

20. Williams S, Trewartha G, Kemp SP, et al. Time loss injuries compromise team success in Elite Rugby Union: a 7-year prospective study. *Br J Sports Med.* 2016;50(11):651-656. doi:10.1136/bjsports-2015-094798

21. Chandran A, Morris SN, Lempke LB, Boltz AJ, Robison HJ, Collins CL. Epidemiology of injuries in National Collegiate Athletic Association women’s volleyball: 2014–2015 through 2018–2019. *J Athl Train.* 2021;56(7):666-673. doi:10.4085/1062-6050-679-20

22. Šiupšinskas L, Garbenytė-Apolinskienė T, Salatkaitė S, Gudas R, Trumpickas V. Association of pre-season musculoskeletal screening and functional testing with sports injuries in elite female basketball players. *Sci Rep.* 2019;9(1):9286. doi:10.1038/s41598-019-45773-0

23. Mendiguchia J, Ford KR, Quatman CE, Alentorn-Geli E, Hewett TE. Sex differences in proximal control of the knee joint. *Sports Med.* 2011;41(7):541-557. doi:10.2165/11589140-000000000-00000