Is Motor Imagery Effective for Prevention of Landing Errors in Volleyball Players: A Randomized Controlled Trial

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OBJECTIVES

The primary aim of this study was to investigate the effect of motor imagery on improving injury-causing factors related to jumps and falls in volleyball players. The secondary aim of this study was to investigate the effect of motor imagery on cortical functions

DESIGN

The study was designed as a randomized controlled trial with three groups: Solo Training (ST), Group Training (GT), and Control groups (CG). Players in ST received motor imagery training individually in addition to routine training programs, while GT group received motor imagery training as group in addition to routine training programs. Both groups were followed up with weekly exercise diaries. The third group was designated as a control group (CG) and continued their routine training program without any motor imagery training. All players were measured before and after the 12-week training programs. All evaluations and training were conducted in a quiet room and at a constant temperature of 24 degrees, where the players could concentrate on the study, and in a room large enough for filming with a camera.

The inclusion criteria were to be between the ages of 15 and 25, not have an injury that affects the player's training program and play regularly for a professional team. Volleyball players who had any lower extremity injury in the last two months and who had been diagnosed with attention deficit hyperactivity disorder at any time were not included in the study.

The participant recruitment period for this study started in May 2025 and ended in September 2025. In total, there were 30 female volleyball players recruited into three groups ST (n=10), GT (n=10), and CG (n=10).

Ethical Approval

Information about the study was disseminated through an advertisement for sports clubs on social media platforms, reaching volunteer players. The ethical suitability of the study was approved by the Sanko University Clinical Research Ethics Committee (No: 2022/17-2). Prior to the commencement of the study, the players were informed of its nature and were requested to provide their and/or their guardian's consent by signing a consent form. Written consent was obtained from the participants. Written consent was obtained from the parents of the minor participants. The participant recruitment period for this study starts on 27.05.2025 and ends on 01.09.2025.

METHODS

Intervention

Prior to the study, a video recording with the correct jump and landing kinematics, showing the correct hip, knee, and ankle flexion angles, was recorded by the researchers. These correct angles for initial contact hip (32.6 ± 11.8), knee flexion (35.1 ± 8.1), knee valgus (0.9 ± 10.4), ankle flexion (-26.7 ± 11.0) and for full contact - peak angles hip (69.1 ± 17.0), knee flexion (59.8 ± 11.0), knee valgus (- 1.1 ± 10.3), ankle flexion (10.7 ± 5.1). The video was a minute long, consisting of front and side angles, and featured a professional volleyball player who was not included in the study. In the present study, the analysis of landing patterns specifically focused on double-leg landings (DL). This preference was primarily based on previous literature indicating that landings in volleyball most frequently occur with both legs (17). Players in ST group individually underwent the training, whereas players in the GT group underwent the training as a group. Players in both groups were trained in a quiet, climate-controlled room. For standardization purposes, no questions were allowed during the training session. In the training session, players were asked to watch the correct landing video at a slightly slower speed and contemplate the appropriate hip, knee, and ankle angles. Then, the researcher explained correct landing mechanics, while referring to the correct landing video, pointed out the common errors, and described how to correct them.

The researcher then explained to the players what MI is and how it works. Following the explanation, players were seated in a comfortable armchair facing the researcher, asked to minimize distracting thoughts, and to be as mindful as possible without speaking for five minutes, and to imagine themselves executing the correct angles during a landing. This MI exercise was assigned as homework to be done three times a day for five minutes for 12 weeks for both groups. The total duration of MI was targeted at 1260 minutes, which is above the suggested total application time of 800-1000 minutes. Players were given weekly exercise diaries to follow up.

OUTCOMES

Kinematic Analysis

The flexion angles of the hip, knee, and dorsiflexion of the ankle during jumping and landing were evaluated with the 'DartfishTM 2-D Motion Analysis Software'. This software possesses simultaneous recording and measurement capabilities and is compatible with mobile phones for installation. This software is employed as a clinical instrument to measure movement amplitude and velocity, biaxial spatial coordinates, and joint angles throughout movement in the volleyball players. Research has demonstrated the Dartfish system's validity and reliability (0.79-0.99) in measuring dynamic movements in both upper limbs and lower limbs across diverse populations.

The players were positioned in front of a wall with a uniform light color to minimize potential distractions during the video recording, and their location was marked on the ground. An iPhone 8 Plus model mobile phone mounted on a tripod at a height of one meter was placed 2 meters away from the participant. Players jumping and landing were recorded from the frontal plane. Then, the player turned 90 degrees, and jumping and landing were recorded from the sagittal plane. The recordings were analyzed and angles were calculated as explained below for two different moments: when the big toe made initial contact with the ground and the moment when the sole made full contact. Videos recorded with Dartfish on the iPhone 8 Plus were captured at a frame rate of 60 Hz.

Hip joint flexion angle: the angle between the line connecting the lateral vertex of the iliac crista and the trochanter major and the angle between the trochanter major and the line running lateral to the knee was measured.

Knee joint flexion angle: the angle between the line connecting the trochanter major and the lateral knee joint and the line running from the lateral aspect of the knee and the line between the lateral malleolus was measured.

Varus-valgus angle of the knee: From the frontal plane was determined as the angle between the line drawn from the patella from the center of the thigh towards the femur and the line descending from the patella towards the lateral malleolus according to the position of the ankle.

Ankle plantar flexion and dorsi flexion angle: the angle between the line from the lateral malleolus to the lateral knee and the line from the lateral malleolus along the fifth metatarsal was measured.

Cognitive Functions

The Computerized Neurocognitive Tests Vital Sign (CNSVS) test consists of 10 standardized neurocognitive tests: verbal memory test, visual memory test, finger tapping test, symbol digit coding test, stroop test (simple reaction test, complex reaction test, and stroop effect), shifting attention test, continuous performance test, perception of emotions test, non-verbal reasoning test, and 4-part continuous performance test. CNSVS uses the results of these tests to calculate 16 domains: neurocognition index (Average of five domain scores: Composite Memory, Psychomotor Speed, Reaction Time, Complex Attention, and Cognitive Flexibility), composite memory (calculated from verbal memory and visual memory tests), verbal memory (ICC=0.32), visual memory (ICC=0.42), psychomotor speed (calculated from finger tapping test) (ICC=0.76), reaction time (ICC=0.75) (calculated from stroop test), complex attention (calculated from Stroop, Shifting Attention, and Continuous performance tests) (ICC=0.56), cognitive flexibility (calculated from shifting attention and stroop tests) (ICC=0.69), processing speed (calculated from simple digit coding test) (ICC=0.67), executive functioning (calculated from shifting attention test) (ICC=0.65), simple attention (calculated from continuous performance test), motor speed (calculated from finger tapping test), working memory (calculated from 4-part continuous performance test) (ICC=0.4), sustained attention (calculated from 4-part continuous performance test), social acuity (calculated from perception of emotions test), and reasoning (calculated from non-verbal reasoning test) (ICC=0.54).

To perform the tests, we have purchased test sessions from CNS-VS website (https://cnsvs.com/), which allowed us to execute the test battery online. The players were placed alone in a quiet room, and were sitting in a comfortable chair in front of a computer with the CNSVS test battery. They were instructed to read the instructions and perform the tests as accurately and as fast as possible.

Randomization

The fixed probability randomization method was utilized as a stratified randomization method. Within each group, the playing positions of the players were homogeneously distributed.

STATISTICAL ANALYSIS PLAN (SAP)

Statistical analyses were conducted utilizing SPSS version 27 software. We investigated the Kinematic variables (Change in hip flexion during initial contact, knee flexion during initial contact, right knee varus degree during initial contact, left knee varus degree during initial contact, ankle flexion during initial contact, hip flexion during full contact, knee flexion during full contact, right knee varus degree during full contact, left knee varus degree during initial contact, ankle flexion during initial contact, hip flexion during full contact, knee flexion during full contact, right knee varus degree during full contact, left knee varus degree during full contact, ankle flexion during full contact) and Cognitive functions (Change in Cognitive Functions: Neurocognition index, composite memory, verbal memory, visual memory, psychomotor speed, reaction time, complex attention, cognitive flexibility, processing speed, executive function, social acuity, reasoning, working memory, sustained attention, simple attention, motor speed) with visual (histograms, probability plots) and analytical methods (Kolmogorov-Smirnov/Shapiro Wilk's test) to determine the normal data distribution. Since, our data showed non-parametric distribution, we used Wilcoxon test for before-after comparisons and Kruskal-Wallis and Mann-Whitney U tests for between group comparisons. The statistical significance level was determined as $p<0.05$. Post-hoc comparisons were made with Bonferroni correction.