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The Effectiveness Of Functional Training On Improving Balance And Injury Prevention In Students

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ABSTRACT

Functional training is a training approach designed to improve the body's ability to perform movements that reflect the movement patterns of daily life and sports activities in an integrated and multi-planar manner. This study aims to examine the effectiveness of functional training on improving balance and preventing injuries in students. The research design used was quasi-experimental with a pre-test and post-test control group design, involving an experimental group (n=30) and a control group (n=30). The experimental group underwent a structured functional training program for eight weeks with a frequency of three times per week, while the control group followed a regular physical training program that is normally conducted. The instruments used include the Y-Balance Test (YBT) for functional balance and the Functional Movement Screen (FMS) to assess movement pattern quality and injury risk. Data analysis was conducted using ANCOVA with the pre-test as a covariate and a significance level of alpha = 0.05. The study results showed that the experimental group experienced a significant increase in all balance variables (YBT: 14,6%) and a significant decrease in injury risk based on FMS scores (from an average of 13.27 to 16.83 out of a maximum score of 21), significantly different from the control group ($p < 0.001$). It was concluded that a structured and progressive functional training program effectively improves functional balance and reduces injury risk in students through comprehensive neuromuscular adaptation mechanisms.

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AUTHORS' CONTRIBUTION

A. Conception and design of the study;
B. Acquisition of data;
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D. Manuscript preparation;
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INTRODUCTION

The world of sport and physical education continues to undergo significant evolution, not only in technical and tactical aspects, but also in the scientific approach to the development of underlying physical abilities. One of the most fundamental developments in the last two decades has been the paradigm shift from muscle isolation-based training to functional training that integrates the entire body system in meaningful and contextual movements (Kodli, 2023). Functional training, conceptually based on the philosophy that the human body is designed to move in integrated patterns involving multiple joints, multiple planes of motion, and coordination across complex kinetic chains, is now increasingly recognized as a more effective approach to developing physical abilities that are truly useful in real-life and sport performance. (Li et al., 2025).

The concept of functional training first developed from physical rehabilitation practice, where physiotherapists recognized that restoring a patient's functional abilities was more effectively achieved through exercises that simulated the movements required in everyday life rather than through isolated muscle isolation exercises. This concept was later adopted and further developed in the context of athletic training by strength and conditioning coaches who found that functional movement-based training programs resulted in better transfer to sport-specific performance than traditional machine-based programs (Niewolak et al., 2022). Today, functional training has become a core component of physical conditioning programs at various levels, from community gyms to the preparation programs of world-class professional sports teams.

In the context of students, especially students in sports and physical education study programs, functional training has very high relevance from two complementary perspectives. First, from the perspective of developing personal physical capacity, sports students need a solid neuromuscular foundation to support their performance in various practical lecture activities, inter-student sports competitions, and high-intensity daily physical activities (Orssatto et al., 2020). Second, from a professional perspective, sports students as prospective physical education teachers, coaches, and fitness instructors in the future require a deep understanding of the principles of functional training that can only be obtained through direct experience of undergoing and feeling the benefits of the program (Gee et al., 2019).

Balance as one of the most critical components of physical fitness is a highly relevant variable to be studied in the context of the effectiveness of functional training. Unlike other components such as strength and endurance which are relatively easy to measure objectively, balance is an integrative function that reflects the quality of coordination between the nervous system, musculoskeletal system, and sensory systems in producing effective postural control (Hwang & Song, 2023). Functional training which inherently involves multi-joint movements in various planes of motion in often unstable conditions provides a very rich and contextual stimulus for the development of the balance control system, which is fundamentally different from the stimulus produced by isolation exercises on machines with controlled and defined motion paths (Mahjur & Norasteh, 2021).

Injury prevention is another aspect of functional training that is receiving increasing scientific attention. Epidemiological data on sports injuries indicate that most non-contact sports injuries result from deficits in neuromuscular control, strength imbalances, and compensatory or inefficient movement patterns. (Song et al., 2022)Instruments such as the Functional Movement Screen (FMS) developed by Cook and Burton have been shown to identify high-risk movement patterns that are significant predictors of injury, and functional training programs targeted to improve these movement patterns have demonstrated significant effectiveness in reducing the incidence of injury in various athletic populations (DePaola et al., 2025).

From a neuromuscular physiology perspective, functional training produces more holistic and transfer-specific adaptations than conventional training. Functional movements involving simultaneous muscle contractions in patterns that mirror actual athletic movements produce neural adaptations in the form of increased efficiency of intermuscular coordination, optimized timing of muscle activation, increased co-contraction of joint stabilizers, and the development of more efficient motor unit recruitment patterns under dynamic and unpredictable movement conditions. (Gee et al., 2019)These adaptations directly contribute to improved functional balance and reduced risk of injury.

Previous studies have confirmed the effectiveness of functional training in various populations. Hartanto and Kusuma (2021) found a significant increase in Star Excursion Balance Test scores of 16.3% in the functional training group compared to 7.2% in the control group after eight weeks of intervention in sports students. Meanwhile, Nugraha and Fauzi (2022) reported a 41% reduction in inadequate (low) FMS scores in a group undergoing a ten-week corrective functional training program. However, research examining the effectiveness of functional training comprehensively using multiple outcome measures that simultaneously encompass balance and injury prevention in Indonesian university students remains very limited, leaving a significant research gap that needs to be filled.

College students as a research population offer several important methodological advantages. First, they are a homogeneous group in terms of age (generally 18–24 years) and educational level, which reduces the variability of covariates that could confound research results (Derks et al., 2018)**.** Second, the college setting allows for tighter control over the implementation of the exercise program, subject attendance, and monitoring for potential injuries throughout the study. Third, the relevance of research findings for the development of physical education curricula in higher education makes the college student population a highly strategic subject for research (Wen, 2023).

One aspect that distinguishes functional training from conventional training approaches is its emphasis on core stability as the foundation of all functional movement. The core muscles, including the transversus abdominis, multifidus, pelvic floor muscles, and diaphragm, form a compression cylinder that supports the spine and transmits force between the lower and upper extremities through the kinetic chain. (J. Kim et al., 2024). Functional training that begins with the development of adequate core stability before progressing to more complex movement exercises creates a solid foundation for continued balance development and injury prevention (J. Kim et al., 2020).

Based on the above descriptions, this study was designed to address the existing knowledge gap by comprehensively investigating the effectiveness of functional training on two primary outcomes: improved functional balance and injury prevention in college students. The hypothesis tested was that the group undergoing a structured functional training program would demonstrate significantly greater improvements in functional balance and a reduction in injury risk compared to the control group undergoing a regular physical training program. The results of this study are expected to provide a meaningful scientific contribution and be directly applicable in the development of evidence-based physical conditioning programs in higher education institutions specializing in sports.

METHODS

The Study Design

This study used a quasi-experimental design with a pre-test and post-test control group design, namely a design involving two different groups of subjects: an experimental group that received functional exercise intervention and a control group that underwent a regular physical exercise program without any specific functional intervention.

The Sample Population Or Subject Of The Research

The research population was all active students of the Physical Education, Health and Recreation Study Program, Makassar State University in the odd semester of 2024. Sampling was carried out using a purposive sampling technique by considering equality between the two groups.

Data Collection Techniques And Instrument Development

The inclusion criteria established for both groups included: (1) actively enrolled students; (2) male; (3) aged 18-23 years; (4) no history of acute musculoskeletal injury in the last three months; (5) no medical conditions that contraindicate moderate to high intensity exercise; (6) not currently undergoing a structured functional exercise or physical rehabilitation program outside the study; and (7) willing to fully participate during the eight weeks of the study by signing an informed consent. Based on the application of these criteria, an experimental group of 30 students and a control group of 30 students were obtained, with no significant differences in demographic characteristics and baseline physical conditions between the two groups based on the initial equality test ($p > 0.05$ for all variables).

This study used four measurement instruments that have been tested for validity and reliability internationally. The Y-Balance Test (YBT) is used to measure functional balance in three main directions (anterior, posteromedial, posterolateral). (Sazdova, 2019)The YBT has been widely validated as a predictor of lower extremity injury risk and provides a composite score that reflects overall functional balance. Third, the Functional Movement Screen (FMS) consisting of seven fundamental movement patterns (deep squat, hurdle step, inline lunge, shoulder mobility, active straight-leg raise, trunk stability push-up, and rotary stability) is used to assess the quality of movement patterns and identify asymmetries and limitations in mobility or stability that are risk factors for injury. Each movement is scored from 0 to 3, with a maximum total score of 21 points. FMS scores below 14 have consistently been shown to correlate with an increased risk of non-contact injury (Jones et al., 2020).

The functional training program administered to the experimental group was structured based on the principles of functional periodization and included four two-week phases. The first phase (weeks 1–2) focused on building a foundation through basic

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mobility and stability exercises, including hip mobility drills, ankle mobility exercises, dead bug, bird dog, and low-intensity pallof presses. The second phase (weeks 3–4) increased complexity by adding single-leg stability exercises such as single-leg RDL, single-leg squat to box, and lateral step-ups, as well as controlled trunk rotation exercises. The third phase (weeks 5–6) introduced more challenging dynamic balance exercises such as single-leg hop and hold, lateral bound and stabilize, and multi-directional lunge matrix with resistance bands. The fourth phase (weeks 7–8) integrated all components into complex conditioning exercises that simulate athletic movement patterns. The control group underwent a regular physical training program that included conditioning runs, general strength training with machines, and static flexibility exercises without specific functional training components.

Data Analysis Techniques

Data analysis was performed using SPSS software version 26. After verifying that the assumptions of normality (Shapiro-Wilk test) and homogeneity of variance (Levene's test) were met, the main analysis used Analysis of Covariance (ANCOVA) with pre-test scores as a covariate to control for any initial differences that may exist between groups.

RESULTS AND DISCUSSION

Characteristics of Research Subjects and Pre-Test Results

Table 1 presents the demographic characteristics and pre-test results of both study groups. Independent Samples T-Test results for categorical variables showed no significant differences between the experimental and control groups on all baseline variables ($p > 0.05$), confirming that both groups were equivalent before the intervention.

Table 1.

Characteristics and Pre-Test Scores of Both Groups (Mean ± SD)

Variables	Experimental Group (n=30)	Control Group (n=30)	p-value
Age (years)	20.23 ± 1.14	20.47 ± 1.08	0.387
Height (cm)	169.7 ± 5.3	170.1 ± 5.8	0.762
Body Weight (kg)	63.4 ± 7.2	64.1 ± 6.9	0.693
Composite YBT (%)	68.47 ± 5.94	69.13 ± 6.24	0.679
FMS Score (out of 21)	13.27 ± 1.76	13.43 ± 1.82	0.718

The mean pre-test FMS scores for both groups (experimental: 13.27; control: 13.43) were below the threshold of 14 consistently identified in the literature as a threshold for injury risk. This indicates that most subjects in both groups had movement patterns that require attention from an injury prevention perspective, providing strong justification for functional intervention. The distribution of FMS scores indicated that deficits were most frequently found in the deep squat, hurdle step, and rotary stability, movement patterns that reflect weaknesses in hip mobility, core stability, and rotational control, key components of functional balance.

Post-Test Results and ANCOVA Analysis

Table 2 presents a comparison of post-test scores and ANCOVA analysis results for all outcome variables. After eight weeks of intervention, the experimental group showed substantial improvements in all balance variables, while the control group showed only minimal and statistically insignificant improvements. ANCOVA analysis with pre-test scores as a covariate confirmed that the differences between the two groups at post-test were statistically significant for all variables ($p < 0.001$) with a large effect size.

Table 2.
Comparison of Post-Test Results and ANCOVA Analysis

Variables	Post-test Ex.	Post-test Cont.	F	p
Composite YBT (%)	83.07 ± 4.87	71.64 ± 5.93	61.27	<0,001
Skor FMS	16,83 ± 1,54	14,17 ± 1,63	47,89	<0,001

The improvement in the composite YBT score (14.6%) in the experimental group reflects comprehensive adaptations in the functional balance control system. From a neuromuscular perspective, the improvement in YBT performance is primarily mediated by an increased ability of the nervous system to integrate proprioceptive input from the joints involved in the single-leg stance movement with visual and vestibular input to produce faster and more accurate corrective motor responses (Sazdova, 2019). Functional training that includes single-leg stability exercises in multiple planes of motion specifically trains this ability through the principle of specificity of training: training conditions that simulate testing conditions produce adaptations that directly improve performance on the measurement instrument (Mancini et al., 2025).

The neuroplasticity mechanisms that occur due to functional training play a central role in explaining the dramatic improvement in balance in the experimental group. Functional training involving complex and unpredictable movements produces functional reorganization in the somatosensory and motor cortices, expanding the cortical representation of the musculoskeletal areas most frequently activated during training. (Taube et al., 2014). Concurrently, cerebellar circuits responsible for motor learning and movement automation undergo synaptic strengthening that enhances the nervous system's feedforward ability to anticipate balance disturbances before they occur, rather than simply responding reactively after balance is disturbed. The transition from predominantly reactive to predominantly predictive balance control is one of the most valuable adaptations produced by a comprehensive functional training program (Iqbal et al., 2023).

The increase in FMS scores from 13.27 to 16.83 in the experimental group is a very important finding from an injury prevention perspective. The transition from a mean score below the injury risk threshold (<14) to a score consistently above the threshold (>14) across all experimental group subjects indicates a fundamental improvement in movement pattern quality that directly correlates with a reduced risk of non-contact injury (Dorrel et al., 2018). Subanalysis of the individual scores for the seven FMS components showed that the greatest improvements occurred in the deep squat (from a mean of 1.73 to 2.53), hurdle step (from 1.83 to 2.47), and rotary stability (from 1.63 to 2.37), which together reflect improvements in hip and ankle mobility, unilateral stability, and trunk rotational control (Nari et al., 2020).

Improvements in the deep squat component of the FMS are significant because the deep squat is a movement pattern that reflects the simultaneous tri-planar mobility and stability of the ankle, knee, and hip, as well as spinal stability in a jointed state of motion. Functional training that includes progressive goblet squats, hip mobility drills, and ankle mobility exercises in the intervention program specifically targets limitations commonly identified in the deep squat component of the FMS (Jones et al., 2020). Improvements in this component not only directly improve FMS scores but also positively impact movement quality in nearly all other functional movement patterns because the deep squat reflects the neuromuscular foundation necessary for these movements (Orth et al., 2021).

The significant contrast between the magnitudes of change in the experimental and control groups provides valuable information about the specific training components responsible for these adaptations. The control group, which underwent a regular physical training program (conditioning running, machine strength training, static flexibility), experienced minimal and clinically insignificant improvements in all outcome variables . These findings confirm that general physical training programs not specifically designed to develop functional balance and movement patterns do not produce significant adaptations in these variables, although they may generally improve physical conditioning in the domains of strength and endurance. This provides strong justification for including functional training as a stand-alone component in physical conditioning programs for sports students (Hillsdon & Foster, 2018).

The practical implications of this study's findings for physical education and sport practice are significant. The substantial improvements in functional balance achieved in eight weeks with a program that does not require expensive equipment demonstrate that functional training is a highly cost-effective investment for educational institutions with limited resources. Furthermore, the improvements in FMS scores, indicating a reduced risk of injury, provide a strong argument for integrating functional training into college students' physical conditioning programs not as an optional option, but as a mandatory component with clear safety implications (Sazdova, 2019).

It should be noted that this study has several limitations that need to be considered when interpreting the results. First, the use of a quasi-experimental design without full randomization limits the strength of causal inferences, although equivalence between the two groups at pre-test was verified. Second, this study involved only male subjects, so the generalizability of the findings to the female population requires further verification. Third, a follow-up period after the exercise program was not conducted in this study, so the long-term sustainability of the adaptations obtained cannot be confirmed. Further research using randomized controlled trials with long-term follow-up and involving more diverse populations is needed to strengthen the conclusions drawn from this study.

CONCLUSION

Based on the research results and discussions that have been described, it can be concluded that a structured, progressive, and periodization-based functional training program implemented for eight weeks with a frequency of three times per week effectively improves functional balance and reduces the risk of injury in students. This is indicated by a significant increase in the composite YBT (14.6%), FMS score (3.56%), in the experimental group, all of which were significantly different from the control group ($p < 0.001$). The improvement in the FMS score from the risk category (< 14) to the safe category (> 14) in all experimental group subjects confirmed the effectiveness of the functional training program in improving the quality of fundamental movement patterns which are predictors of injury risk.

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