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## Comparison of Lower Limb Alignment (Genu Varum, Genu Valgum, Genu Recurvatum, and Foot Posture) Between Rope-Skipping and Non-Rope-Skipping Boys Aged 11–13 Years

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ARTICLE INFO	ABSTRACT
<p>Article History:            Received 16 February 2019            Received in revised form 3 May 2019            Accepted 12 June 2019            Available online 19 June 2019</p>	<p>The lower limbs, in addition to serving as the base of support, are also the main means of locomotion. The presence of any abnormalities in these limbs can cause considerable difficulties in daily life and sports activities. Therefore, the aim of the present study was to compare the lower limb alignment in 11–13-year-old rope-skipping and non-rope-skipping male students. The statistical population of this study included all 11–13-year-old male students in Abhar city during the 2018–2019 academic year. Among these students, 35 boys who had at least three years of rope-skipping experience were selected using a questionnaire, and another 35 students were randomly chosen as the control group. Genu varum and genu valgum deformities were assessed using the IM–IC index. A universal goniometer was employed to measure genu recurvatum, and the Staheli index was used to evaluate foot posture. Data were analyzed using SPSS version 22. The Shapiro–Wilk test was applied to check the normality of data distribution, and independent t-tests were used to determine differences between the groups. The findings revealed significant differences in the prevalence of lower limb abnormalities between the rope-skipping and non-rope-skipping groups (<math>p = 0.001</math> for genu varum, <math>p = 0.021</math> for genu valgum, <math>p = 0.026</math> for genu recurvatum, and <math>p = 0.036</math> for foot posture). Based on the results of this study, it can be concluded that engaging in rope-skipping activities for at least three years may help prevent or reduce lower limb abnormalities.</p>
<p>Keywords:            Rope Skipping, Patellar Malalignment, Varus/Valgus Knee Alignment, Posterior Knee Position, Foot Posture.</p>	

### 1. INTRODUCTION

Rope skipping is one of the activities that most sports science specialists consider a complete physical exercise. This sport has positive effects on various components of physical fitness [1–3]. Among the key principles of

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corrective movements is maintaining the health of the musculoskeletal system, which is particularly important among elementary school students. Structural problems in the musculoskeletal system of students can reduce their self-confidence, potentially leading to numerous personal and social issues in the future.

The lower limbs, in addition to serving as the base of support, are also the main means of locomotion. The presence of abnormalities in these limbs can cause serious problems in performing daily and sports activities. Considering the importance of this issue, one of the responsibilities of sports science researchers is to identify the types of exercises that can strengthen and correct the muscles especially those of the lower extremities.

According to research conducted in developed countries, more than 70% of children and adolescents suffer from lower limb weaknesses. Such abnormalities have considerable physical, psychological, social, and economic effects on individuals and society. Since students constitute a large part of the population, previous studies have shown that this group often suffers from muscular and joint pain and fatigue. The high prevalence of lower limb deformities also results in significant medical and therapeutic costs.

Studies have demonstrated that muscular weakness is one of the main causes of these abnormalities. Maintaining a natural and correct body posture is a basic human necessity. Proper posture not only reflects a person's physiological and anatomical health but also indicates internal balance and well-being. In addition to hereditary factors, postural deformities are also associated with the so-called "diseases of civilization," such as those arising from mechanized and industrialized lifestyles (Odia, 2011). Therefore, designing appropriate exercise programs to strengthen muscles and prevent postural abnormalities is essential.

These abnormalities can be corrected through various methods, such as manual therapy, postural retraining, taping, and exercise therapy, with the latter being one of the most common approaches [4]. The main goal of corrective movements is to eliminate physical weaknesses, particularly among children and adolescents [5]. Today, there is increasing emphasis on modern approaches to correcting musculoskeletal deformities, especially the age-appropriate prescription of corrective exercises. Given that the rehabilitation process through corrective movements is relatively long and sometimes tedious, the design of enjoyable and age-appropriate exercise programs becomes crucial.

In addition to corrective methods, preventive approaches also play an important role in reducing musculoskeletal deformities. One modern preventive approach involves exercise programs aimed at addressing risk factors such as muscle weakness, imbalance, and improper alignment. However, traditional corrective exercises are often limited and may not be suitable for children and adolescents [6]. Moreover, corrective exercise programs are usually monotonous and tiresome, leading to low adherence among young individuals, even when they are aware of their postural issues.

The importance and value of play during childhood have been strongly supported by extensive research. Play affects social, emotional, cognitive, and educational development and has both diagnostic and therapeutic value [7]. It is an inseparable part of life and an effective means of fostering optimal functioning and cognitive growth [8]. Therefore, employing corrective and enjoyable physical activities that are both therapeutic and recreational is particularly suitable for addressing postural abnormalities in children.

Rope skipping is a complete and enjoyable physical activity that can be performed individually, in pairs, or in groups. It enhances cardiovascular endurance, metabolism, coordination, muscular strength, and stamina [1–3]. Rope skipping allows individuals to engage in vigorous activity in limited space and serves as an entertaining and even competitive sport among students, motivating them to participate due to its joyful nature [3].

Accordingly, the present study aims to compare lower limb abnormalities between rope-skipping and non-rope-skipping students to determine whether rope skipping can contribute to the correction and improvement of lower limb malalignments

## **2. MATERIALS AND METHODS**

The present research is a field-based comparative study conducted on male students aged 11 to 13 in the academic year 98-97 in Abhar County. With permission from the relevant education authorities, the study was conducted in schools within Abhar County. Following an explanation of the thesis and the procedure of tests in plain language, students with a minimum of 3 years of rope skipping experience were selected using an information registration form and by performing basic jump rope movements. Subsequently, 35 individuals were randomly chosen from this group as the experimental group, and another 35 individuals were randomly selected from the remaining students as the control group. The selected students were given a consent form to participate in the study and were required to be present in a sports hall on a designated day for conducting the tests. This research received ethical approval with the code IR.UT.SPORT.REC.1398.002.

The test procedures were explained to each participant before initiation. All tests were conducted in a single session, and the results were recorded on the relevant forms. A 5-minute rest period was provided between tests to prevent fatigue. It is noteworthy that all tests in the jump rope and non-jump rope groups were entirely identical.

Inclusion criteria consisted of having no history of injury, fractures, specific limb-related surgeries [9], no history of professional sports activities [9], and the absence of sensory-motor disorders [10]. The exclusion criteria included experiencing injuries during the research period, becoming ill or starting medication during the research, and participants' unwillingness to continue participating in the study.

In this study, lower limb abnormalities included genu recurvatum, genu varum, genu valgum, and foot posture. The following method was employed to measure these abnormalities:

For measuring genu recurvatum and genu varum, the IM-IC index was used. The participant, wearing sports shorts without shoes and socks, stood comfortably facing the examiner on a smooth and vertical surface with legs parallel to each other. The internal condyles of the thighs and the medial malleoli of the ankles were in close proximity, and the thighs and knees were in full extension. Subsequently, while the participant looked straight ahead, the mid-foot arch, indicating the distance between the internal condyles of the knees, was measured by the examiner using a plastic caliper (the largest and smoothest prominence in the upper part of the knee joint, inclined backward, is considered as the internal condyles of the knee).

Additionally, the distance between the internal malleoli was measured using a caliper (the prominent bony part at the end of the tibia, in the upper part and ankle joint, is considered as the internal malleoli). In this study, individuals with an IM-IC index less than (3-) centimeters were classified as having genu recurvatum, individuals with an IM-IC index between (3-) to (3+) centimeters as normal knees, and individuals with an IM-IC index greater than (3+) centimeters as having genu varum [11-14] (Figure 1).



**Fig. 1.** Measurement of bracket and cross knee

To measure genu recurvatum, the participant stood naturally in an upright position with feet shoulder-width apart. Three anatomical landmarks the greater trochanter of the femur, the lateral epicondyle of the knee, and the lateral malleolus were identified. The angle formed between these three points was then measured using a long-arm

universal goniometer, and the degree of knee hyperextension was recorded. In a normal condition, this angle ranges from 0° to 5° [12, 15] (Figure 2).



**Fig. 2.** Measurement of Genu Recurvatum

To evaluate foot posture, the medial longitudinal arch of the foot was assessed using the footprint technique. The participant's foot was coated with baby powder, and after several seconds of natural walking, the subject was asked to step onto a pre-positioned plexiglass plate placed on the ground without paying attention to it. The resulting footprint was then analyzed using the Staheli Arch Index. A Staheli index value of less than 0.44 was classified as high arch (pes cavus), a value between 0.44 and 0.89 was considered normal, and a value greater than 0.89 was defined as flat foot (pes planus) [12, 14, 16] (Figure 3).



**Fig. 3.** Assessing the condition of the soles of the feet

After data collection, statistical methods at two descriptive and inferential levels were employed, using SPSS version 22 software. Descriptive statistics were utilized to calculate central tendencies and dispersions, while inferential statistics were applied for hypothesis testing. The Shapiro-Wilk test was initially used to assess the normality of the data, followed by the independent t-test to determine differences between groups. The significance level throughout the study was set at 95% with an alpha of 0.05.

### 3. RESULTS

The participants' individual characteristics are presented in Table 1. The two groups were largely comparable in terms of mean individual characteristics, and no significant differences were observed between them.

**Table 1.** Anthropometric Characteristics of Participants (Mean  $\pm$  SD)

Group	N	Age (years)	Height (cm)	Weight (kg)
Rope Skippers	35	12.28 $\pm$ 0.92	151.71 $\pm$ 9.48	46.45 $\pm$ 8.22
Non-Skippers	35	12.25 $\pm$ 0.88	155.77 $\pm$ 8.87	53.20 $\pm$ 12.34
P-value	70	0.480	0.071	0.183

Descriptive statistics for the study variables are summarized in Table 2.

**Table 2.** Descriptive Statistics of Study Variables (Mean  $\pm$  SD)

Group	N	Genu Varum (cm)	Genu Valgum (cm)	Recurvatum Knee ( $^{\circ}$ )	Arch Index (cm)
Rope Skippers	35	0.00 $\pm$ 0.00	0.50 $\pm$ 0.00	12.21 $\pm$ 0.21	0.64 $\pm$ 0.14
Non-Skippers	35	1.00 $\pm$ 6.00	1.00 $\pm$ 6.00	33.42 $\pm$ 1.42	0.71 $\pm$ 0.18

The Shapiro–Wilk test indicated that the data were normally distributed ( $p > 0.05$ ), allowing for the use of parametric statistical tests. Independent-samples t-test results are presented in Table 3.

**Table 3.** Independent-Samples t-Test Results Comparing Lower Limb Abnormalities Between Groups

Variable	df	t	P
Arch Index	62	-1.00	0.036
Genu Varum	68	1.00	0.001
Genu Valgum	68	-2.00	0.021
Recurvatum Knee	57	2.01	0.026

As shown in Table 3, significant differences were observed between rope skippers and non-skippers in the prevalence of genu varum, genu valgum, recurvatum knee, and flat or high-arched feet.

#### 4. DISCUSSION

The present study indicates a significant difference in lower limb abnormalities between rope-skipping and non-rope-skipping students. The results show that students with at least three years of rope-skipping experience exhibited more normal lower limb alignment compared to their non-rope-skipping peers.

Despite extensive searches, no previous scientific studies were found that directly examined the effects of rope-skipping exercises on lower limb abnormalities. Therefore, in the absence of comparable research, this study does not attempt to compare its findings with other studies but instead focuses on analyzing and discussing the potential mechanisms through which rope-skipping exercises may influence lower limb abnormalities.

In this study, the exercises considered were the basic rope-skipping movements, which include ten techniques: basic jump, forward-backward jump, butterfly jump, front scissors, zigzag jump, jogging step, toe-to-toe jump, lateral scissors, heel-to-heel jump, and waist rotation [1, 2, 17] (Appendix 1). As illustrated in these figures, performing rope-skipping engages all lower limb muscles, leading to their strengthening, which may help prevent or correct lower limb abnormalities.

For example, regarding foot arch abnormalities, studies on muscle activity in individuals with flat feet indicate that stabilizing muscles such as the peroneus longus are less active compared to those with normal foot structure [18, 19]. The heel-to-heel rope-skipping movement (Figure 11), performed with forward leg positioning, strengthens the anterior lower leg muscles, such as the peroneus longus, thereby potentially preventing or correcting flat foot deformities. Although precise data on the number of participants performing this movement were not available in

the present study, rope-skipping in general enhances the strength of ankle and plantar muscles [1, 2], which likely contributes to the prevention and correction of foot-related abnormalities.

Regarding genu varum (bowlegs) and genu valgum (knock-knees), prolonged imbalance in muscle length either stretching of the lateral knee muscles and shortening of the medial muscles in genu varum, or the reverse in genu valgum alters force patterns on the knee joint over time, leading to these deformities [20, 21]. For instance, the butterfly jump (Figure 6) strengthens both medial and lateral knee muscles proportionally, which can help prevent or correct these abnormalities. Overall, rope-skipping increases strength in major muscles of the thigh, knee, and ankle [1, 2], addressing one of the main causes of genu varum and genu valgum, namely muscle imbalance. By proportionally strengthening these muscles, rope-skipping may correct or prevent these knee deformities.

For genu recurvatum (hyperextended knee), weakness of the quadriceps can impair propulsive force during push-off, hamstring weakness can lead to compensatory hip flexion and knee extension, calf muscle spasm can stiffen the ankle, extensor muscle spasm during stance phase, and knee flexor (hamstring) weakness can all contribute to excessive knee hyperextension [22, 23]. Additionally, imbalance between agonist and antagonist muscles can exacerbate this deformity [24]. Rope-skipping movements such as jogging (Figure 9), toe-to-toe (Figure 10), scissors (Figures 7 and 11), and heel-to-heel (Figure 12) strengthen the quadriceps and hamstrings, potentially preventing or correcting genu recurvatum.

In summary, the findings suggest that muscle weakness and imbalance in lower limb musculature may contribute to the development of lower limb abnormalities. Rope-skipping exercises enhance the strength of major muscles in the thigh, knee, and ankle [1, 2] and promote balanced muscle function, which may prevent or correct lower limb deformities.

## **5. CONCLUSION**

This study does not claim a cause-and-effect relationship in the context of jump rope exercises and prevention of abnormalities. However, it is evident that the group engaged in jump rope activities for a minimum of three years exhibited better lower limb alignment compared to the non-athlete control group. This indirect observation suggests a potential positive impact of jump rope exercises on lower limb alignment.

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## **Transparency Statement**

The data supporting this study are available upon reasonable request to the corresponding author, subject to ethical and confidentiality considerations.

## **Declaration of Interest**

The authors declare that they have no competing interests.

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