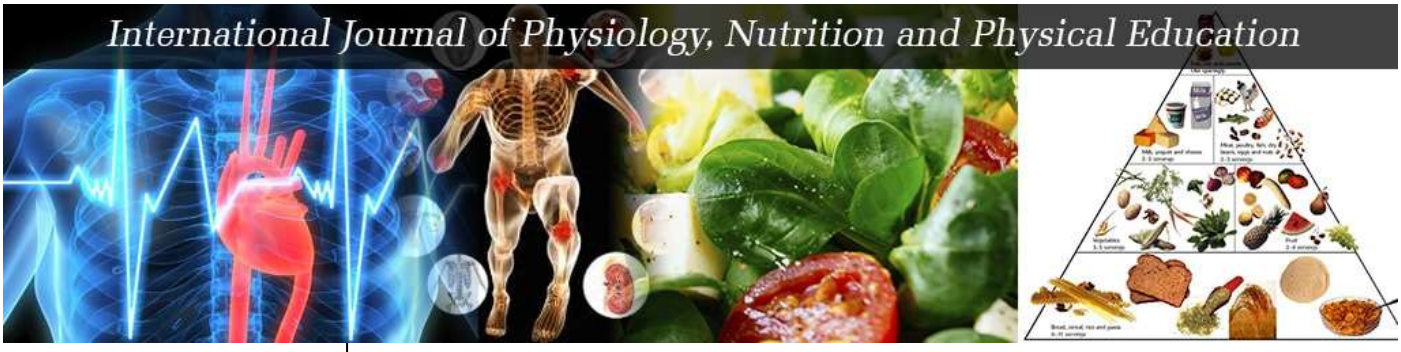

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Improving lower limb muscle power, agility, and aerobic endurance in healthy adolescent boys through plyometric exercises and agility ladder drills

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Abstract
This study aimed to enhance leg muscle power, agility, and aerobic endurance in 13-15-year-old boys by integrating plyometric exercises with agility ladder drills. A cohort of 45 participants underwent pretest and post-test assessments, measuring vertical jump performance, agility through the T-Test, and aerobic endurance with the multistage fitness test. Data were analysed using descriptive statistics, the Wilcoxon signed-rank test, and the Mann-Whitney U test. Significantly improved power (P=0.006), agility (p=0.001), and endurance (P=0.001) were observed within the experimental group. Comparing the experimental and control groups revealed notable differences in agility (P=0.000) and endurance (p=0.000), with no significant variance in power (P=0.416). These findings highlight the positive effects of combining plyometric exercises and agility ladder drills on the physical performance of 13-15-year-old boys, recommending this approach for enhancing power, agility, and endurance.

Keywords: Agility, basketball, training, endurance

Introduction
Basketball, a team-based sport, is widely popular among individuals spanning various age groups (Rahmi & Bachtiar, 2020) [43]. Players pursue diverse objectives such as recreation, health enhancement, and achievement (Young *et al*., 2011; Bloshchynsky *et al*., 2019) [52, 6]. Attaining excellence in basketball demands concerted effort for optimal outcomes. Early development in basketball lays the foundation for success, necessitating a comprehensive and structured coaching program (Balyi, Way & Higgs, 2013) [5], backed by internal and external resources (Bompa & Buzzichelli, 2019) [8]. While technical training plays a key role, the physical dimension is integral (Taware, Bhutkar & Surdi, 2013) [48], emphasizing the significance of robust physical conditioning. A holistic approach to training is vital for young players, enriching their technical execution and facilitating intricate movements (Brendan *et al*., 2014) [10]. Physical exercise's impact on cognitive-muscle coordination underscores the importance of varied, brain-engaging workouts for young athletes (Faigenbaum *et al*., 2016) [18]. In this context, optimizing basketball training for 13-15-year-olds requires distinct strategies (Buśko *et al*., 2012) [12]. However, in-depth research on this specific age group is needed. Coaches must tailor training to athletes' developmental stages, employing scientific approaches for long-term excellence (Alsaudi, 2020) [2]. Mastery may not be immediate, but nurtured methods culminate in mature champions. Plyometrics, denoting explosive movements, serve to enhance physical capacities (Jastrzbeski *et al*., 2014) [26], encompassing swift eccentric and concentric phases (Radcliffe & Farentinos, 2015) [42]. Plyometrics offer gains in power, agility, flexibility, and endurance (Pratama *et al*., 2018) [41]. While technique holds importance, physical fitness underpins technical execution (Yudhistira & Tomoliyus, 2020) [53]. Furthermore, numerous instructors indicated that plyo- metrics training was not allowed to be offered to young athletes due to the risk of injury, then the coach stated that various conditions must be met before plyometrics training, such as the athlete being able to complete squats weighing 1.5 body weight (Jones & Ledford, 2012) [27]. This is right, but it is not suitable; in reality, plyometrics exercise, when done with the appropriate training dose, has

a favourable influence on the development of young athletes' physical condition (Rubley *et al*, 2011) [46]. Gjinovci *et al*. (2017) [21] conducted an experimental study on young Basketball players for 12 weeks utilizing a skill- based plyometrics training approach, with the outcomes of plyometrics training having a substantial influence on 20-meter running, leaping ability, and effectively lowering body mass index. Then, according to Idrizovic (2018) [24], physical activity utilizing the plyometrics training approach gives a considerable rise in ball medicine throwing and the capacity to leap vertically in junior Basketball competitors. However, according to Fathi *et al*. (2019) [19], plyometrics training had no significant effect on enhancing jump height, sprint time, and flexibility in teenage Basketball players. According to the findings of Maćkała, plyometric training did not result in a substantial increase in vertical jump performance in Basketball players. Based on the studies discovered, there are contradictions in earlier research. Studies on plyometrics training methods are still being debated (Ramirez-Campillo *et al*., 2020) [44]. Furthermore, Gjinovci *et al*. (2017) [21] claimed that there is still little study that investigates plyometric training approaches mixed with various motions to promote Basketball abilities. The goal of this study is to investigate the plyometrics training approach employing agility ladder drills to develop leg muscular strength, aerobic endurance, and agility in Basketball players aged 13-15 years.

Methodology

Study Participants

In this study, a field test experiment was conducted using both a one-group pretest-post-test design and a pretest-post-test control group design. The participants consisted of 45 male basketball players aged 13-15, with heights ranging from 157 to 170 cm and body weights between 57 and 67 kilograms. The initial stage involved a pretest that evaluated vertical leap, agility via the t-test, and aerobic fitness using the multistage fitness test. The collected data were subsequently ranked and organized in ascending order. The A-B-B-A pattern was utilized for ordinal pairing matching, resulting in the division of the experimental group into two subgroups: One comprising 15 players engaged in plyometrics training with agility ladder drills, and the other involving 15 players who underwent diverse training methods. With the guidance of two trainers, the research implemented plyometrics agility ladder drill training for both groups of 15 basketball players aged 13-15. The training occurred twice a week over 16 sessions, each session lasting approximately 90 to 120 minutes, with exercise intensity adjusted as needed.

Research Design

Participants received treatment in the form of plyometrics training incorporating agility ladder drills over the course of 16 sessions, with sessions conducted twice weekly. Participants were required to have a minimum attendance rate of 80%. The study employed the vertical leap test to assess leg muscle power, the agility t-test to measure agility, and the multistage fitness test to gauge aerobic endurance. The plyometrics agility ladder drill exercises were executed in a systematic manner: The athlete began with a 3 to 5-minute jog to elevate heart rate, followed by static and dynamic stretching lasting approximately 20 to 30 minutes. Subsequently, the prepared plyometrics program was executed, integrating agility ladder drills.

Statistical Analysis

Data processing was conducted using the SPSS version 23 program. The analysis commenced with descriptive statistics, presenting minimum, maximum, standard deviation, and mean values. The subsequent stage encompassed Wilcoxon analysis to discern differences between pretest and post-test effects within the experimental group. Additionally, Mann-Whitney analysis was employed to identify disparities between post-test outcomes of the experimental and control groups. Statistical significance was determined by a significance value < 0.05. The physical abilities of power, agility, and aerobic endurance were described in detail in Table-1 and 2.

Table 1: Descriptive analysis results of pretest and post-test power agility and endurance (Control Group)

Variable	Pretest				Posttest				
	Min	Max	Mean	SD	Min	Max	Mean	SD	Sig
Power	39	51	48.71	4.51	40	51	48.11	3.18	0.065
Agility	16.09	18.65	16.15	0.40	16.19	19.04	16.65	0.51	0.091
Endurance	37.10	47.10	42.33	2.76	38.21	47.04	43.71	2.32	0.083

Table 2: Descriptive analysis results of pretest and post-test power agility and endurance (Experimental Group)

Variable	Pretest				Posttest				
	Min	Max	Mean	SD	Min	Max	Mean	SD	Sig
Power	38	52	49.73	4.80	49	57	52.53	4.59	0.019
Agility	16.12	19.12	17.01	0.47	17.75	16.00	17.10	0.32	0.041
Endurance	36.19	47.18	44.69	3.24	49.18	51.88	51.32	1.02	0.030

Results

The Wilcoxon analysis was conducted to assess the significance (2-tailed) of changes in the leg muscle power variable. The obtained value of 0.019, which is less than the critical threshold of 0.05, signifies a notable enhancement in leg muscular power between the pretest and post-test evaluations. Similarly, in the agility variable, the calculated value of 0.041, again falling below the 0.05 threshold, indicates a substantial discrepancy in agility outcomes when comparing the pretest and post-test results. Furthermore, the analysis of the endurance variable revealed a value of 0.030, below the significance level of 0.05, suggesting a significant alteration in endurance between the pretest and post-test measurements. Interestingly, a comprehensive examination of the gathered data presented in Table 1 contradicts the significance found in the Wilcoxon analysis. Despite the initial statistical findings, the detailed assessment of all selected variables demonstrates no substantial disparities between the pretest and post-test outcomes. This conclusion arises from the fact that the p-values for all variables exceed

the threshold of 0.05, indicating a lack of statistical significance.

Discussion

In the discussion of the research findings, the Wilcoxon analysis performed on the pretest and post-test data revealed insightful results. Specifically, the power variable within the experimental group displayed a significant improvement with a value of 0.019, which is less than the established threshold of 0.05. Similarly, the agility variable demonstrated a value of 0.041, and the endurance variable exhibited a value of 0.030, both falling below the significance level of 0.05. These outcomes signify a noteworthy distinction between the pretest and post-test measurements, indicating that the post-test scores surpassed the pretest values. This is evidenced by the observed average post-test scores of 52.53 for power, 17.10 for agility, and 51.32 for endurance within the experimental group. In contrast, the control group did not exhibit comparable improvements. Basketball necessitates the execution of intricate actions such as passing and repeated jumping, which are inherent in the game's demands (Boichuk *et al*., 2017; Budiman, 2016) [7, 11]. The significance of physical fitness resonates not only with seasoned athletes but also with young athletes (Faigenbaum *et al*., 2016) [18]. Indeed, the fusion of astute strategies and tactics with a robust physique is integral to success (Franchini *et al*., 2007) [20]. The devised plyometrics training program tailored for basketball players aged 13-15 evidently holds considerable efficacy. The improvements observed across the power, agility, and endurance variables within the experimental group affirm the positive impact of this training regimen. This underscores the importance of systematic and well-structured training approaches in enhancing the physical capabilities of young athletes in the context of basketball.

Conclusion

In conclusion, the culmination of findings and subsequent discussions underscores the significant impact of the pretest-post-test comparison within the experimental group. This impact is particularly pronounced in terms of leg muscular power, agility, and endurance. Consequently, the incorporation of plyometrics training, coupled with agility ladder drills, emerges as a highly recommended exercise regimen for young basketball players and other sports that entail intricate motion enrichment. The empirical evidence presented herein emphasizes the potential of this training approach in fostering comprehensive physical development among athletes in their formative years.

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