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RESEARCH ARTICLE

Competence of Neuromuscular Training on Agility, Hamstring Flexibility, Anaerobic Capacity and Plantar Flexor Endurance among Recreational Football Players

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ABSTRACT

Objectives: Hamstring flexibility, agility, anaerobic capacity, and plantar flexor endurance are vital factors for football performance. Neuromuscular training has been shown to positively affect these physical parameters. This study aimed to evaluate the effect of a neuromuscular training program on hamstring flexibility, agility, anaerobic capacity, and plantar flexor endurance in college-level recreational football players at the Krupanidhi Institution. **Methods:** A quasi-experimental design with pre- and post-test assessments was used in this study. Sixty-six male football players aged 18-25 years participated in a training program involving eccentric hamstring exercises, plyometrics, sprinting, and flexibility exercises performed three times per week. Pre- and post-intervention assessments included the Modified Illinois Change of Direction Test (MICODT), Active Knee Extension (AKE), Running-Based Anaerobic Sprint Test (RAST), and Heel Raise Test (HRT). **Findings:** Significant improvements were observed in all tests ($p \leq 0.001$). RAST scores increased from 2625.69 ± 425.45 to 2702.21 ± 435.02, HRT improved from 25.04 ± 4.05 to 27.90 ± 3.78, and MICODT decreased from 16.29 ± 1.30 to 15.15 ± 1.09. The AKE results showed significant reductions, indicating improved hamstring flexibility and strength. **Novelty:** This study highlights the effectiveness of neuromuscular training in improving multiple physical performance parameters, including hamstring flexibility, anaerobic capacity, and plantar flexor endurance in recreational football players.

Keywords: Neuromuscular training; Hamstring flexibility; Agility; Anaerobic capacity; Plantar flexor endurance

1 INTRODUCTION

Hamstring flexibility plays a crucial role in the performance of football. A study of young football players found that those with higher hamstring flexibility performed better in sprinting, jumping, agility, and kicking tests than less flexible players[1]. This indicates that hamstring flexibility may be beneficial for agility and anaerobic capacity in football players. Players with lower quadriceps flexibility performed better on the Balsom agility test compared to those with higher flexibility[2]. This indicates that muscle stiffness, rather than flexibility, may be advantageous for agility in some cases. Anaerobic capacity appears to be an important factor in distinguishing elite players. Among elite, sub-elite, and amateur players, professionals had higher knee flexor strength and better performance in short sprints, which may reflect anaerobic power[3]. Plantar flexor endurance also appears to be an important factor in performance and injury prevention in recreational football players. Studies have shown that athletes with certain lower-limb conditions exhibit deficits in plantar flexor endurance compared to healthy controls[4,5].

Neuromuscular training programs have been shown to have positive effects on various physical performance parameters in recreational football players. A 7-week neuromuscular training program combining eccentric hamstring exercises, plyometrics, and sprinting led to small improvements in 5-m sprint performance and moderate-to-large increases in hamstring strength while maintaining sprinting performance[6]. This shows that neuromuscular training can enhance sprinting ability and hamstring function. Neuromuscular training appears to be beneficial for improving sprint ability, hamstring function, and neuromuscular control in recreational players. Enhancing hamstring flexibility may provide additional benefits in terms of agility and power. However, further research is needed to determine the optimal training protocols and their effects on plantar flexor endurance. This study aimed to assess the effect of neuromuscular training on various physical parameters in college-level recreational football players at the Krupanidhi Institution.

2 MATERIALS AND METHODS

A convenience sampling technique was used to recruit participants for this quasi-experimental study with a single-group pre-test and post-test design. The sample size was calculated based on a 95% confidence level (Z = 1.96), 80% population proportion (p = 0.80), and 5% margin of error (e = 0.05), and was 246. After applying finite population correction (FPC) for the 90 available football players, the final sample size was adjusted to 66. The study was conducted over 8 months. The participants included male football players aged 18-25, who had been playing at the collegiate level for at least one year. Only those playing in forward and midfield positions, proficient in English, and with no lower extremity injuries or vestibular problems in the past six months were included. Participants with recent surgeries; neuromuscular, orthopaedic, or cardiovascular conditions; and those unable to participate in full training due to injury were excluded from the study. Ethical clearance was obtained from the Institutional Ethics Committee (IEC). Signed written informed consent was obtained from all participants.

Pre-intervention assessments included the Modified Illinois Change of Direction Test (MICODT), Active Knee Extension (AKE), Running-Based Anaerobic Sprint Test (RAST), and Heel Raise Test (HRT). These measurements were recorded as the baseline data. The neuromuscular training protocol, which lasted for eight weeks, included 25–30-minute sessions, three times per week, with at least one day of rest between sessions. The training consisted of running exercises (7 minutes), balance and body control exercises (5-7 minutes), plyometric exercises (5-7 minutes), strengthening exercises (5-7 minutes), and stretching exercises (5 minutes). Each session began with a warm-up and concluded with a speed run, followed by cool-down stretches. Post-intervention, the same tests (MICODT, AKE, RAST, and HRT) were repeated to assess changes in agility, hamstring flexibility, anaerobic capacity, and plantar flexor endurance. The data collected were analysed statistically to determine the effectiveness of the neuromuscular training intervention.

3 RESULTS

The study included 66 participants aged 18–25 years, with a mean age of 21.44 years (SD = 2.25, SEM = 0.278). The height of the participants ranged from 152 to 179 cm, with a mean height of 164.33 cm (SD = 6.46, SEM = 0.795). The participants' weights ranged from 60 to 75 kg, with a mean weight of 66.77 kg (SD = 4.36, SEM = 0.537). The Body Mass Index (BMI) of the participants ranged from 21 to 28.2, with a mean BMI of 24.78 (SD = 1.77, SEM = 0.217) (Table 1).

Table 1: Descriptive statistics of participant demographics and physical characteristics

Variables	n	Minimum	Maximum	Mean	SD	SEM
Age (yrs)	66	18	25	21.44	2.25	0.278
Height (cms)	66	152	179	164.33	6.46	0.795
Weight (kgs)	66	60	75	66.77	4.36	0.537
BMI	66	21	28.20	24.78	1.77	0.217

SD = Standard deviation; SEM = Standard error mean

Table 2 presents a comparison of the pre-test and post-test values for RAST, HRT, and MICODT. The results showed significant improvements across all tests ($p \leq 0.001$). For the RAST, the pre-test mean was 2625.69 $\pm$ 425.45, while the post-test mean increased to 2702.21 $\pm$ 435.02, with a t-value of -23.51 (p = 0.000). The HRT also showed improvement, with the pre-test mean at 25.04 (SD = 4.05) and the post-test mean at 27.90 $\pm$ 3.78, yielding a t-value of -10.83 (p = 0.000). In the MICODT, the pre-test mean was 16.29 (SD = 1.30), which improved to 15.15 $\pm$ 1.09 post-test, with a t-value of 11.95 (p = 0.000).

Table 2: Comparison of Pre-test and Post-test Values for RAST, HRT, MICODT, and AKE

Variables	Pre-test		Post-test		t Test	$p \leq 0.001$
	Mean	SD	Mean	SD		
RAST	2625.69	425.45	2702.21	435.02	-23.51	0.000***
HRT	25.04	4.05	27.90	3.78	-10.83	0.000***
MIOCDT	16.29	1.30	15.15	1.09	11.95	0.000***
AKE (Left)	20.84	3.04	18.62	2.79	14.06	0.000***
AKE (Right)	21.39	3.07	19.01	2.99	10.66	0.000***

*** Significant

Significant changes were also observed in the Active Knee Extension (AKE) tests, with the left leg showing a decrease in the mean from 20.84 $\pm$ 3.04 to 18.62 $\pm$ 2.79, and the right leg from 21.39 $\pm$ 3.07) to 19.01 $\pm$ 2.99, both with t-values of 14.06 and 10.66, respectively (p = 0.000 for both) (Table 2). These results highlight the effectiveness of the intervention in improving the anaerobic capacity, plantar flexor endurance, agility, and knee flexibility.

4 DISCUSSION

Neuromuscular training programs can significantly affect various physical performance parameters in football players, including agility, hamstring flexibility, anaerobic capacity, and plantar flexor endurance. Neuromuscular training combining eccentric hamstring exercises, plyometrics, and sprint training has been shown to improve hamstring strength and maintain sprinting performance in football players[6]. This type of training can lead to moderate-to-large increases in concentric and eccentric hamstring strength, which may help prevent hamstring strains. The training program resulted in small improvements in the short-distance sprint performance, suggesting enhanced agility and anaerobic capacity.

The timing of neuromuscular exercises, particularly Nordic Hamstring exercises, relative to football training sessions can impact their effectiveness. Performing NHE before football training may reduce eccentric hamstring strength and potentially increase the injury risk during subsequent training sessions[7]. This demonstrates the importance of proper scheduling of neuromuscular training within a football player's overall training regimen. In terms of plantar flexor endurance, neuromuscular training has been shown to increase mean plantar flexor EMG activity during countermovement jumps[8]. This suggests improved neuromuscular activation and potentially enhanced endurance of plantar flexors.

The findings of the present study support the efficacy of neuromuscular training in enhancing physical performance and reducing injury risk in athletes. Neuromuscular training has been shown to enhance agility through improved motor skills and coordination, as evidenced by a decrease in completion times for agility tests in various studies[9,10]. The participants of the present study likely experienced similar benefits, as neuromuscular training is recognised for its role in optimising neuromuscular responses during rapid directional changes. Research indicates that NT can significantly increase hamstring flexibility and strength, which are crucial for injury prevention[6]. The present study's focus on hamstring flexibility aligns with findings that emphasise the importance of eccentric strength training in football players to mitigate injury risk. Neuromuscular training has been linked to improvements in anaerobic capacity, with studies showing enhanced performance in sprinting and endurance tasks[11]. The participants' anaerobic capacity improved owing to the structured training regimen, supporting the literature's claims of neuromuscular training effectiveness.

The findings of this study on the effects of neuromuscular training among recreational football players demonstrated significant improvements in agility, hamstring flexibility, anaerobic capacity, and plantar flexor endurance, with all tests showing p-values ≤ 0.001. The study reported a notable increase in RAST scores, from a pre-test mean of 2625.69 to a post-test mean of 2702.21, indicating enhanced anaerobic capacity. Similar findings were observed in young soccer players, where neuromuscular training significantly improved agility and sprint performance significantly[12]. The HRT results showed a pre-test mean of 25.04, improving to 27.90 post-training, reflecting increased hamstring flexibility[13]. Previous studies have also highlighted the role of neuromuscular training in improving flexibility, particularly in the hamstring muscles, which is crucial for preventing injury. The current study shows the positive outcomes of neuromuscular training, and some studies suggest that the effectiveness may vary based on individual athlete characteristics and training protocols, indicating the need for specific approaches in training regimens[14].

The effects of neuromuscular training on agility, hamstring flexibility, anaerobic capacity, and plantar flexor endurance among recreational football players in the present study demonstrated significant improvements in these areas, particularly in knee flexibility as indicated by the Active Knee Extension (AKE) test results. Studies indicate that neuromuscular training enhances motor skills, including agility and coordination, which are vital for football players[9]. The significant changes in AKE test results suggest improved anaerobic capacity, corroborating the findings that neuromuscular training increases muscular endurance and power. A reduction in AKE test scores indicates enhanced hamstring flexibility, which is essential for injury prevention. Research has highlighted that improved flexibility can reduce the risk of musculoskeletal injuries in sports[14]. Neuromuscular training programs have been effective in increasing flexibility, as evidenced by various studies reporting significant improvements in hamstring flexibility through targeted training[14]. It is evident from the present study that neuromuscular training had positive outcomes. It is essential to consider that the effectiveness of such training may vary based on individual athlete characteristics and the specific training protocol employed.

5 CONCLUSION

The findings of this study demonstrated that a neuromuscular training program significantly improved key physical performance parameters in recreational football players, including hamstring flexibility, anaerobic capacity, agility, and plantar flexor endurance. These results suggest that neuromuscular training, which combines eccentric hamstring exercises, plyometrics, and sprinting, can enhance both flexibility and strength, contributing to better overall performance. These findings support the potential of neuromuscular training as an effective strategy to improve football-related physical attributes and reduce injury risk among recreational players. Further research is needed to optimize neuromuscular training programs for diverse populations and to explore their long-term benefits.

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