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Research Article

Sports Medicine -Based Isokinetic Rehabilitation of the Quadriceps in Knee Osteoarthritis

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Efficacy of Isokinetic Muscle Strengthening Training in Knee Osteoarthritis: A Randomized Controlled Trial

Abstract

The randomized controlled trial assessed the efficacy of isokinetic muscle strengthening training (IMST) in individuals with knee osteoarthritis (KOA). Participants were randomly assigned to either an IMST group or a control group receiving standard physiotherapy. Over a 12-week intervention period, the IMST group underwent structured isokinetic exercises targeting knee flexors and extensors. Outcomes measured included peak torque (PT), total work (TW), average power (AP), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and the 6-minute walk test (6MWT). The IMST group demonstrated significant improvements in PT, TW, and AP at both 60°/s and 180°/s angular velocities ($p < 0.001$). Additionally, significant reductions in WOMAC scores ($p < 0.01$) and enhancements in 6MWT distances ($p < 0.05$) were observed. These findings suggest that IMST effectively enhances muscle strength and functional performance in KOA patients, surpassing the benefits of standard physiotherapy. The study underscores the potential of IMST as a superior intervention for improving physical function and quality of life in individuals with knee osteoarthritis.

Keywords: Isokinetic training, Knee osteoarthritis, Muscle strength

Introduction

Knee osteoarthritis (KOA) is a prevalent degenerative joint disorder characterized by the progressive deterioration of articular cartilage, subchondral bone remodeling, and synovial inflammation, leading to pain, stiffness, and functional limitations. The global burden of KOA is substantial, with increasing incidence attributed to aging populations and rising obesity rates. Conventional management strategies encompass pharmacological interventions, physical therapy, and, in advanced cases, surgical procedures. However, the quest for effective non-pharmacological interventions that can alleviate symptoms and improve functional outcomes remains a priority in KOA management.[1-3]

Muscle weakness, particularly in the quadriceps, is a hallmark of KOA and contributes significantly to joint instability and disease progression. Strengthening exercises targeting the lower limb musculature have been advocated to mitigate these effects. Isokinetic muscle strengthening training (IMST) offers a controlled environment where muscle contractions occur at a constant speed, allowing for maximal muscle loading throughout the range of motion. This modality has shown promise in enhancing muscle strength and functional capacity in various musculoskeletal conditions.[4-7]

Recent studies have explored the efficacy of IMST in KOA patients, demonstrating improvements in muscle strength, pain reduction, and functional performance. For instance, a meta-analysis encompassing 33 randomized controlled trials reported significant enhancements in peak torque, total work, and average power of knee flexors and extensors following IMST. Moreover, reductions in pain scores and improvements in functional assessments such as the WOMAC and 6MWT were observed. These findings underscore the potential of IMST as a valuable intervention in KOA rehabilitation.[8-10]

Despite these promising results, there remains a need for high-quality randomized controlled trials to further elucidate the benefits of IMST in KOA management. This study aims to evaluate the efficacy of a structured IMST program in improving muscle strength, pain, and functional outcomes in individuals with KOA, providing insights into its potential role in clinical practice.

Methodology

This randomized controlled trial was conducted to assess the efficacy of isokinetic muscle strengthening training (IMST) in individuals diagnosed with knee osteoarthritis (KOA) at BMCH Quetta. Participants aged between 45 and 70 years, with radiographically confirmed KOA (Kellgren-Lawrence grade II or III), were recruited from outpatient clinics. Exclusion criteria included prior knee surgery, inflammatory joint diseases, neurological disorders affecting lower limb function, and participation in other structured exercise programs within the past six months.

Sample size calculation was performed using Epi Info software, considering a power of 80%, a significance level of 0.05, and an expected effect size based on previous studies. The estimated sample size was 60 participants, with 30 individuals allocated to each group. Participants provided verbal informed consent before enrollment.

Participants were randomly assigned to either the IMST group or the control group using a computer-generated randomization sequence. The IMST group underwent a 12-week supervised isokinetic training program focusing on knee flexors and extensors, with sessions conducted thrice weekly. Training intensity was progressively increased based on individual performance. The control group received standard physiotherapy, including range of motion exercises, stretching, and low-resistance strengthening exercises.

Outcome measures were assessed at baseline and after the 12-week intervention period. Primary outcomes included peak torque (PT), total work (TW), and average power (AP) of knee flexors and extensors, measured using an isokinetic dynamometer at angular velocities of 60°/s and 180°/s. Secondary outcomes encompassed the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) for pain and function assessment and the 6-minute walk test (6MWT) for functional mobility evaluation.

Data analysis was performed using SPSS software. Within-group comparisons were conducted using paired t-tests, while between-group differences were assessed using independent t-tests. A p-value of less than 0.05 was considered statistically significant.

Results

Table 1: Demographic Characteristics of Participants

Variable	IMST Group (n=30)	Control Group (n=30)	p-value
Age (years)	58.2 ± 6.5	57.8 ± 6.8	0.78
Gender (M/F)	12/18	13/17	0.79
BMI (kg/m²)	27.5 ± 3.2	27.8 ± 3.5	0.65
Duration of KOA (years)	4.2 ± 1.1	4.0 ± 1.3	0.54

Table 2: Isokinetic Strength Measurements

Parameter	IMST Group Pre	IMST Group Post	Control Group Pre	Control Group Post	p-value (Between Groups)
PT Flexors 60°/s (Nm)	45.3 ± 5.2	55.6 ± 5.8	44.8 ± 5.5	46.2 ± 5.7	<0.001
PT Extensors 60°/s (Nm)	65.7 ± 6.1	78.9 ± 6.4	66.1 ± 6.3	67.5 ± 6.5	<0.001
TW Flexors 180°/s (J)	320.5 ± 25.4	385.7 ± 28.6	322.1 ± 26.1	330.2 ± 27.3	<0.001
TW Extensors 180°/s (J)	450.3 ± 30.2	520.8 ± 32.5	448.7 ± 31.4	455.6 ± 33.1	<0.001
AP Flexors 60°/s (W)	60.2 ± 4.5	70.1 ± 4.8	59.8 ± 4.6	61.0 ± 4.7	<0.001
AP Extensors 60°/s (W)	80.5 ± 5.3	92.3 ± 5.6	81.0 ± 5.4	82.5 ± 5.5	<0.001

Table 3: Functional Outcome Measures

Outcome Measure	IMST Group Pre	IMST Group Post	Control Group Pre	Control Group Post	p-value (Between Groups)
WOMAC Score	45.6 ± 5.7	30.2 ± 4.9	46.1 ± 5.9	42.8 ± 5.5	<0.01
6MWT Distance (meters)	380.4 ± 35.2	420.7 ± 38.6	382.1 ± 36.5	390.3 ± 37.8	<0.05

The IMST group exhibited significant improvements in muscle strength parameters, including peak torque, total work, and average power, at both tested angular velocities. Functional assessments demonstrated notable reductions in WOMAC scores and enhancements in 6MWT distances, indicating improved pain levels and functional mobility. The control group showed minimal changes across these measures.

Discussion

The findings of this randomized controlled trial underscore the efficacy of isokinetic muscle strengthening training (IMST) in enhancing muscle strength and functional outcomes in individuals with knee osteoarthritis (KOA). The significant improvements observed in peak torque, of knee flexors and extensors in the IMST group align with recent literature demonstrating that targeted isokinetic resistance training elicits superior neuromuscular adaptations compared to conventional exercise modalities[16]. These adaptations are crucial in KOA patients, where muscle weakness is not only a consequence but also a contributor to disease progression.[11-13]

Notably, improvements in total work and average power at varying angular velocities suggest enhanced muscular endurance and functional strength, critical factors in preserving joint stability and reducing mechanical stress on the knee joint during daily activities. The angular velocity-specific gains reflect the velocity-dependent nature of isokinetic training, which ensures comprehensive recruitment of both slow- and fast-twitch muscle fibers.[14-16]

In terms of functional performance, the IMST group demonstrated substantial reductions in WOMAC scores and significant gains in 6MWT distance. This supports previous findings that improved muscle strength translates into better pain modulation and enhanced ambulatory capacity in KOA patients. These functional improvements directly impact quality of life and independence in this population, underscoring the clinical relevance of IMST.[17-19]

Moreover, the specificity and adaptability of isokinetic resistance training contribute to its success, allowing individualized intensity progression, minimizing risk of injury, and ensuring optimal biomechanical control. Unlike standard physiotherapy approaches, IMST's objective feedback and quantifiable metrics enable precise monitoring and adjustment of training parameters.[20]

The minimal improvements seen in the control group, despite receiving standard physiotherapy, highlight the superior efficacy of IMST in inducing measurable and meaningful clinical outcomes. These findings are consistent with recent controlled trials advocating for structured resistance-based rehabilitation strategies as primary interventions for KOA management.

Importantly, the integration of isokinetic training may also offer preventive benefits by decelerating cartilage degeneration and delaying the need for surgical interventions such as total knee arthroplasty. This aligns with evidence suggesting that muscle-strengthening programs may modulate inflammatory pathways and improve joint proprioception, thereby altering the course of KOA progression.

However, despite the promising outcomes, broader implementation of IMST is limited by the availability and cost of isokinetic dynamometry systems. Future studies should investigate the feasibility of incorporating simplified or portable versions of such equipment in routine clinical settings and community-based rehabilitation programs.

Longitudinal studies are also warranted to evaluate the durability of the observed effects and assess whether periodic reinforcement training is necessary to sustain benefits. Moreover, integrating biomarkers of inflammation and cartilage degradation in future research may provide mechanistic insights into how IMST influences the underlying pathology of KOA.

In conclusion, this study contributes to the growing body of evidence supporting the use of high-intensity, controlled resistance training for KOA. The statistically and clinically significant improvements in muscle strength and function reaffirm the value of IMST as a pivotal component in contemporary rehabilitation protocols.

Conclusion

Isokinetic muscle strengthening training produced statistically significant improvements in muscle strength, pain reduction, and functional performance among individuals with knee osteoarthritis. This study addresses critical gaps in existing rehabilitation protocols by providing evidence for a targeted, measurable intervention with superior outcomes compared to standard physiotherapy.

Future work should focus on long-term follow-up and scalable implementation of this promising training modality.

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