Review Article :

Exercise Training's Impact on Multifidus Muscle Thickness in Patients with Lower Back Pain: A Systematic Review

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Abstract

Various previous studies showed that there is involvement of multifidus muscle in lower back pain patients. Atrophy of lumbar multifidus is commonly witnessed among LBP patients. However, there is a lack of scientific findings regarding the training of this muscle. It is still unknown what changes are caused in the multifidus by such training methods. Therefore, the aim of this review is to explore the impact of various training techniques on the thickness of the multifidus muscle in patients with chronic or nonspecific back pain. Various international databases like Google Scholar, Scopus Elsevier, Web of Science, and PubMed were searched by using a combination of keywords like "Exercise", "Multifidus", "Thickness" and "Lower Back Pain". PEDro scoring was used for the assessment of the quality of included RCTs in the present review. It was found that there are few studies that showed improvement in the thickness of lumbar muscles due to different types of training but without investigating lumbar multifidus specifically. Isokinetic training and core stabilization exercises have been found to improve the thickness and symmetry of the multifidus muscle, as well as aid in muscle atrophy recovery. Isokinetic exercises and core-strengthening routines have been shown to enhance the multifidus muscle's thickness and symmetry, and also assist in reversing muscle atrophy. It can be used to improve the knowledge of physical therapists and LBP patients who are suffering from chronic or nonspecific back pain.

Keywords:
Multifidus, Exercise, Training, Thickness, Back pain.

Introduction

Low back pain (LBP) is a highly prevalent form of pain that frequently arises from a lack of core stability[1]. Previous studies[2-5] have emphasized the vital role of the multifidus muscle in stabilizing the core and enabling dynamic control. A prior investigation revealed the occurrence of

selective atrophy of the multifidus muscle in patients with chronic LBP, as determined with computed tomography (CT scan)[6].

Kader et al. likewise observed multifidus atrophy in 80% of chronic LBP subjects through Magnetic Resonance Imaging (MRI) studies[7]. This atrophy leads to spinal instability thus; it is an important factor for recurrence of LBP. Previous studies reported persistent involvement of multifidus in subjects suffering from LBP. For example, reduced activity of muscle, fatty infiltration and atrophy have been reported in these patients[8-15]. There is an inhibitory feedback mechanism in response to pain leading to localized muscle atrophy which ultimately leads to reflex inhibition of lumbar multifidus causing atrophy and fatty infiltration in the muscle[16]. Different exercises were used by physiotherapists to train or recruit the deep lumbar muscles, especially the multifidus muscle of the lumbar region[17,18].

Previous literature suggested that segmental muscle stabilization training and isolated training of lumbar extensors positively affect morphology and improve the cross-sectional area of the lumbar multifidus, thus improving pain [19,20]. However, evidence showcasing alterations in the anatomical features of this muscle remains elusive, particularly in patients with chronic or nonspecific LBP. Therefore, it was proposed to review the studies using diagnostic imaging as a reference point to examine how different training programs affect multifidus muscle thickness in people with chronic or nonspecific LBP. To evaluate the same, the author has considered the articles published after 2015 with PEDro score of at least >=5/10 following the PICO method [21-23].

Material and Methods

International databases like Google Scholar, Scopus Elsevier, Web of Science and PubMed were searched using a combination of keywords like "Exercise", "Multifidus", "Thickness" and "Low Back Pain" for articles published between January 2015 till May 2023. Studies published before the year 2014 were excluded. PEDro scoring (quality assessment) of included studies was shown in Table1. The retrieved articles were screened based on the defined inclusion and exclusion criteria. The steps are clearly depicted in the PRISMA flowchart (Figure 1). The studies included in the review (having =>5 score on PEDro) were finally assessed by the efficacy of the treatment[13].

Inclusion criteria and Exclusion criteria: The publications which satisfied the criteria were considered for the review. The study should be (a) a Randomized Controlled Trial (RCT)/or single-group exper-

imental study on low back pain patients and (b) published in the English language only. Studies published in other language other than the English language, systematic reviews or any case report studies were excluded.

Quality assessment:

An 11-item checklist scale (PEDro) was used to evaluate the quality of included studies (Table1).

Types of Exercise Interventions:

All studies contained multifidus strength training/resistance training/ progressive strength training as the main or a component of the treatment of chronic LBP.

Data extraction and analysis:

Study design, subject characteristics, problem, interventions and outcome measures were extracted. The findings extracted from the RCTs were not comparable therefore, statistical analysis was inappropriate. Table 2 shows a summary of all extracted data from included studies in a narrative form.

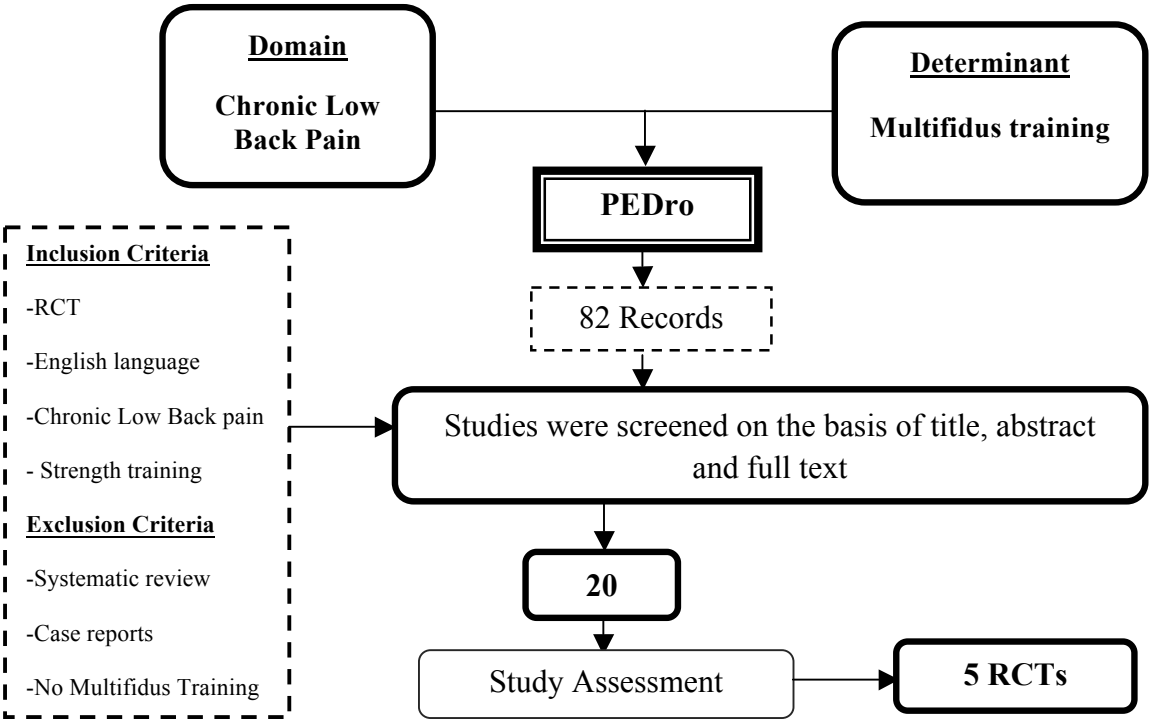


Figure 1. Stepwise flowchart of methodology for selection of studies.

A total of 82 articles were identified. Based on the screening for inclusion/ exclusion, 20 were included. Based on the Multifidus muscle thickness as an outcome measure and minimum score of 5 and above PEDro score, out of 20, 5 RCTs were included in the final analysis (Table 1).

Results

A total of five studies was considered for the present review. Quality scores of all included RCTs using PEDro scale is shown in Table 1. A detailed summary of included studies under the following sections: author, design, number of patients, age, treatment applied, duration/follow-up of treatment, outcome measures, results, and conclusion are presented in Table 2

Table 1: The outcome of the evaluation of methodological quality based on the PEDro scale.

Author, Year	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	Overall PEDro score
Nambi et al., 2022[22]	√	√	x	√	x	x	√	√	√	√	√	7
Narouei et al., 2020[24]	√	√	x	√	x	x	√	√	x	√	√	6
Kim et al., 2018[25]	√	√	x	√	x	x	√	√	√	√	√	7
Nabavi et al., 2018[26]	√	√	x	0	x	x	√	√	x	√	√	5
Berglund et al., 2017[27]	√	√	x	√	x	x	x	√	x	√	√	5

*Note: (i) Requirements for participation; (ii) Unbiased assignment; (iii) Concealed distribution; (iv) Initial group similarities; (v) Concealment of participants; (vi) Therapists unaware of group assignments; (vii) Evaluators unaware of group assignments; (viii) Sufficient tracking over time; (ix) Analysis based on initial group assignment; (x) Comparisons across groups; (xi) Central values and range of variability.

Table 2: Findings of included studies.

S. No.	Authors	Study Design	Age	Sample Size	Interventions	Duration/ Follow up	Outcome measures	Results	Conclusion
1	Nambi et al., 2020[22]	Randomized Clinical Trial	18-25 years	60	Isokinetic(IKT) versus Virtual reality exercises	4 weeks/ 5 days a week	MF Muscle thickness measured using Diagnostic USG	The IKT group displayed a decline in pain, biochemical markers, and radiological indicators compared to the CST and Control groups	IKT > VR Exercises**
2	Narouei et al., 2020[24]	Prospective, Randomized and Controlled Trial	18-45 years	32	Core Stabilization versus Conventional PT Treatment	4 Weeks	MF Muscle thickness measured using Diagnostic USG	Core stabilization exercises fared better than conventional treatment causing a decrease in VAS, Oswestry Disability scale	CST > CE*
3	Kim et al., 2018[25]	Randomized Prospective Clinical Trial.	18-40 years	40	Horizontal versus Vertical Vibration exercises	12 weeks	MF Muscle thickness measured using Diagnostic USG	Both the treatment groups showed similar improvement with a low recurrence rate of CLBP	HVE = VVE (NS)
4	Nabavi et al., 2018[26]	Randomized Comparative Clinical Trial	18-50 years	41	Lumbar Stabilization exercises (LSE) with Electrotherapy versus conventional therapy(CT)	4 weeks	MF Muscle thickness measured using Diagnostic USG	Lumbar stabilization exercises relieved symptoms better than conventional treatment using VAS & DI	LSE > CT*

S. No.	Authors	Study Design	Age	Sample Size	Interventions	Duration/ Follow up	Outcome measures	Results	Conclusion
5	Berglund et al., 2017[27]	Randomized Double Blind Controlled Trial	25-60 years	61	Low Load Motor Control(LLMC) Exercises versus High Load lifting (HLL)	8 weeks	MF Muscle thickness measured using Diagnostic USG	LLMC fared better than HI exercises in all parameters including PS-FS(patient Specific functional scale) and VAS.	LLMC > HIE*

*- Statistically significant (p< 0.05), ** - Statistically significant (p< 0.001)

Discussion

The effects of Training on the muscle groups have been studied earlier. However, studies employing Multifidus muscle thickness measurements by diagnostic ultrasonography as outcome measures are scarce. The present review summarizes the findings of the studies with relevant conclusions. For the same PeDro was used to evaluate the studies and highlight their strengths. One notable study is by Nambi et al.[22] (with a PEDro score of 7). In this research, the author contrasted the impacts of two training modalities: isokinetic training and core stabilization training, specifically in football players suffering from LBP. The double-blinded RCT involved 60 participants, aged between 18 to 25 years, all of whom had experienced back pain for a duration exceeding three months. The participants were divided into three distinct groups: Isokinetic Training (IKT), Core Stabilization Training (CST), and a Control group, with each group comprising 20 individuals. For the IKT regimen, participants were positioned on an isokinetic dynamometer with their knees mildly bent at a 15-degree angle and were then guided to keep their range of motion between an extension of 100 degrees and a flexion of 80 degrees. After acclimatization to the training, participants were directed to execute the exercise at angular velocities of 60, 90, and 120 degrees and were made to perform 15 repetitions for three sets, with a 30-second rest interval between each set. The second experimental group (CST) group received balance training with Swiss ball (bridging, sit-ups, side bridge, arms leg cross lifting 10 times-3 sets)[23] whereas the control group underwent traditional balance training, which included isotonic and isometric exercises targeting the abdominal and back muscles. This training regimen lasted for 4 weeks and was conducted 5 days a week. The results indicated a significant enhancement in the cross-sectional area (measured using a diagnostic ultrasound device) of the psoas major (PM), multifidus (Mf), quadratus lumborum (QL), and erector spine (ES) muscles in the IKT group compared to both the CST and Control groups. The study overall indicated that, for football

players with chronic LBP, the IKT group displayed a decline in pain, biochemical markers, and radiological indicators compared to the CST and Control groups. Thus, it can be inferred that this may serve as a novel training protocol for various sports injuries across multiple athletic disciplines.

The second study by Narouei et al.[24] demonstrated that a four-week program of core stabilization exercises effectively increased the contracted thickness of the Gluteus maximus (G max), Transverse abdominis (TrA), and Multifidus (MF), while also reducing disability. The study was done on 32 individuals assigned into two groups of 17 (experimental) and 15 (control) participants. The experimental group was instructed to carry out core stabilization exercises and progressed through 4 levels for four consecutive weeks whereas the control group received conventional physiotherapy treatment using Transcutaneous Nerve Stimulation (TENS) and hot packs. The bilateral activity of muscles was assessed by using ultrasound imaging and surface electromyography. The researchers observed statistically significant temporal effects on the resting muscle thickness of key muscles in the region, including the Transversus Abdominis (TrA) muscle (P= 0.01), the Multifidus (MF) muscle (P= 0.041), and the Gluteus Maximus (G max) muscle (P= 0.003). In a similar vein, the study found statistically significant effects of exercise on the contracted muscle thickness of the transversus abdominis (TrA) (P= 0.032) and gluteus maximus (G max) (P= 0.026). However, no statistically significant effects were detected for the contracted thickness of the multifidus (MF) at the L5 level.

The third study, conducted by Kim et al.[25] with a PEDro score of 7 examined the impact of horizontal and vertical vibration exercise on those experiencing chronic LBP. The study involved a sample size of 40 participants, divided into two groups, which involved a daily time frame of thirty minutes of exercises, thrice weekly, over a span of twelve weeks. The experiments were performed in both the anteroposterior and mediolateral orientations, with each orientation The participants in the High Vertical Excursion (HVE) group were involved in activities that took place in the Anteroposterior plane, using frequency range of 3-5 Hz and an amplitude range of 1-48 mm whereas experiments were performed within the VVE group, where vertical vibrations were administered along the vertical axis, frequency range spanned from 28 to 34 Hz, while the amplitude varied between 2.5 and 5 mm. The results showed that no significant changes in muscle thickness were observed in either the

transversus abdominis (TrA) or multifidus muscles in the high-volume exercise (HVE) group (p=0.153 for TrA, p=0.737 for multifidus) or the very high-volume exercise (VVE) group (p=0.561 for TrA, p=0.380 for multifidus), a notable enhancement in muscle strength was evident. The findings of the study indicated non-significant differences in muscle thickness seen among the groups for both the transversus abdominis (p=0.568) and multifidus (p=0.906).

In a further study, Nabavi et al.26 conducted a randomized controlled experiment using 41 subjects (PEDro score = 5). The intervention used was lumbar stabilization exercises in conjunction with electrotherapy whereas the control group engaged in routine exercises with electrotherapy modalities. The intervention was implemented for a duration of 60 minutes, with a frequency of three sessions per week, spanning a total of four weeks. The assessment of pain severity was conducted using the Visual Analog Scale (VAS), while the evaluation of muscle dimensions was performed using rehabilitative ultrasonography. A statistically significant improvement was observed in both pain severity and muscle dimensions ($p<0.01$) following a 4-week intervention period as well as presence of diminished size and muscular asymmetry of the multifidus muscle in the lower back region.

Last but not least, Berglund et al.[27] (PEDro score=5) compared the effect of low-load motor control (LMC) exercises versus high-load lifting (HLL) exercises on lumbar multifidus. It was also determined whether or not the impact was influenced by pain severity. The RCT involved 61 participants diagnosed with mechanical LBP with each group (n=20) receiving LMC exercises and HLL exercises for two months respectively. Dead lift was the only exercise in HLL exercises (performed with weight) whereas the LMC exercises involved both the static and dynamic exercises that were performed without any external resistance. Multifidus muscle thickness was measured at the level of L5 vertebra using rehabilitative ultrasound imaging. It was found that lumbar multifidus thickness improved significantly on the smaller side as compared to the larger side in both intervention groups, with more improvement visualized in the LMC group. However, changes in pain intensity have no effect on its thickness.

The current review found only a few studies that used diagnostic imaging as an end metric to evaluate the effects of specialized training on the multifidus muscle thickness in chronic or nonspecific LBP. Pain and inhibition of the muscles lead to muscular weakening, which reduces the cross-sectional area and muscle thick-

ness[28]. Previous research also confirmed that the thickness of the Multifidus is reduced because of degenerative alterations in the intervertebral discs[29]. The first research, by Nambi et al., looked at how IKT, CST, and conventional training affected the cross-sectional area and paraspinal muscle thickness in chronic LBP patients. Prior to undergoing training, participants with LBP showed reduced size in specific back muscles, including the Psoas major, Quadratus lumborum, Multifidus, and Erecter spinae. A 4-week isokinetic training showed notable growth in these muscles' cross-sectional areas for the group receiving this type of training, distinguishing it from those who underwent core stability training and those in the control group. This indicates that isokinetic training can be beneficial in various sports [22]. One reason for muscle thickening, particularly in the Multifidus, could be the increased activity of fibroblasts in the discs when training at different speeds[30]. Separately, Narouei and his team found that 4 weeks of core stability exercises led to an increased resting thickness in the TrA, Mf, and G max muscles for patients with non-specific chronic LBP. Additionally, exercises for the core resulted in increased thickness of the TrA and G max muscles[24].

Core stabilization exercises restore correct contractions of muscles by motor learning. Core stabilization exercise was an effective method to improve core muscle thickness. There is a study in the present review in which no improvement was seen in the thickness of lumbar muscles. Kim et al. discovered that both the HVE and VVE groups improved in pain, disability, balance, and lumbar muscular strength, however, the hypertrophy of the TrA and multifidus muscles was found to be non-significant[25]. Similarly, no differences in muscle dimensions or pain intensity were found between the groups in the second research, which compared changes in the two groups.

In the context of non-specific chronic LBP, there is evidence to suggest that both regular exercise regimens and stabilizing exercise regimens have demonstrated efficacy in alleviating pain and reducing the dimensions of the transversus abdominis (TrA) and multifidus (Mf) muscles. Nevertheless, it was observed that stability exercises demonstrated greater efficacy in augmenting the thickness of the multifidus muscle[26]. Berglund et al. conducted a recent study wherein they observed a significant augmentation in lumbar multifidus thickness on the smaller side relative to the bigger side in both intervention groups. This increase in thickness was observed without any notable impact on pain intensity[27]. In contrast to the aforementioned

findings, a previous study conducted by Danneels et al.[32] revealed that the incorporation of a combined regimen of stabilization training and dynamic-static resistance training yielded a significant augmentation in the cross-sectional area of the multifidus muscle bilaterally, accompanied by a notable alleviation of discomfort. Previous research has demonstrated that targeted motor control training has the potential to enhance muscle symmetry by increasing muscle thickness[33,34].

The variations in muscle size can be explained by the physiological reactions of the multifidus muscle to several types of muscle activity, specifically pure dynamic and a combination of static and dynamic exercises. Empirical research indicates that activities incorporating an isometric phase are likely to result in a greater accumulation of metabolites. This phenomenon could potentially contribute to the transition as a result of two elements. To begin with, it is worth noting that the duration of these workouts is significantly longer in comparison to their dynamic mode counterparts. Additionally, the static nature of these activities induces elevated intramuscular pressure, leading to a significant decrease in oxygenation.

The metabolic stimulus for skeletal muscle hypertrophy is a subject of ongoing scholarly discourse. Weight-bearing workouts that induce intense muscular contractions lead to significant mechanical stress inside the muscle, accompanied by a substantial metabolic cost[2]. Nevertheless, it is worth noting that there exists supporting evidence indicating the substantial metabolic expenditure associated with physical activity. Research evidence indicates that dynamic training alone does not result in hypertrophy, whereas the deliberate implementation of mixed dynamic-static stress appears to be essential for achieving an increase in muscle volume. This discovery implies that metabolic factors may have a substantial impact on this phenomenon[35].

The implication of the results is evident in those cases where the client/patient leads a sedentary lifestyle. In the present world where everything is technology-driven, people are becoming dependent upon all types of digital services, where active physical activity is taking a back seat. This is particularly important for both adults as well as children of the millennial generation where the back muscles are not subjected to workloads that are high enough to excite type II muscle fibers and maintain their normal size, resulting in muscular atrophy and weakness which again is majorly contributing to back aches whenever the person is subjected to unaccustomed activity or continuous stress over a certain time period.

Clinical significance

The data from the present review provided information about the type of training, number of repetitions and duration of training. Isokinetic training and core stabilization exercises seem to be effective methods for improving the thickness of lumbar multifidus in chronic or nonspecific LBP patients, thus, ultimately leading to a reduction in pain.

Conclusion

Present review findings are unable to record, which exercise training is the best to improve the thickness of lumbar multifidus in LBP patients. However, it was revealed by the present study that Isokinetic training exercises, core stabilization, and core strengthening exercises can significantly improve the thickness of the lumbar multifidus. Muscular atrophy can be recovered by these exercise training methods. The outcomes of the current study can be utilized to enhance the knowledge and skills of physical therapists and LBP patients who are suffering from chronic or nonspecific back pain.

1. Isometric activities, for their prolonged duration and immobile character, result in a larger accumulation of metabolites than other kinds of activity.
2. Isometric workouts take far longer to complete than dynamic ones, resulting in a greater buildup of metabolites.
3. Due to the high intramuscular pressure induced by the static activities, muscle oxygenation drops dramatically during the isometric phase of a workout.
4. Mixed dynamic-static stress, rather than dynamic training alone, is essential for achieving muscle hypertrophy, contributing to an increase in muscle volume.
5. Isokinetic training and core stabilization exercises have been found to significantly enhance the thickness of the lumbar multifidus muscle.

Conflict of interest

None

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