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ORIGINAL

EVALUATION OF THE EFFECT OF MICRODISCECTOMY AT THE LOWER LUMBAR LEVELS ON SAGITTAL VERTICAL AXIS AND SAGITTAL BALANCE IN A SERIES OF 102 BODY BUILDERS: SPORTS HEALTH IMPLICATIONS

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ABSTRACT

Individuals involved in body building frequently experience sagittal imbalance, a prevalent issue observed in the spinal setting. Nevertheless, there has been a lack of adequate evidence to enhance the understanding of the matter among sports organisations, coaches, and body builders. Furthermore, individuals diagnosed with lumbar disc herniation (LDH) who participate in body building have shown a high prevalence of this issue. Therefore, microdiscectomy is a highly efficacious surgical intervention for the treatment of this medical issue. The primary objective of this research is to assess the impact of microdiscectomy on the sagittal vertical axis and sagittal balance in a cohort of 102 body builders with sagittal imbalance in Turkey. The study aims to shed light on the significant consequences for sports health in this setting. The study examined several spinopelvic characteristics, including sacral slope (SS), pelvis incidence (PI), pelvis tilt (PT), thoracic kyphosis (TK), sagittal vertical axis (SVA), and lumbar lordosis (LL). However, we only considered the degree of trunk shift to assess coronal alignment. Furthermore, the researchers also documented the "electromyography (EMG) index". The findings derived from this investigation demonstrated that all participants successfully regained their sagittal and coronal balances after undergoing discectomy. A notable disparity was noted in the sagittal vertical axis (SVA) across the entire spinal column, both prior to (11.7 ± 6.7) and after the surgical procedure (0.51 ± 2.7) ($p < 0.050$).

Significant outcomes were observed in both the parameters related to the pelvic region and the spine. Following the surgical intervention, there was a notable decrease in the angle of TK, namely from 24.8 ± 11.4 to 22.1 ± 9.7 ($p < 0.050$). Simultaneously, the angle of LL exhibited a notable enhancement from an initial value of 25.4 ± 14.1 to 42.5 ± 10.4 following the surgical intervention ($p < 0.050$). However, following the surgical procedure, there was a noticeable increase in the average angle of SS, which rose from 25.7 ± 9.6 to 30.41 ± 8.8 ($p < 0.050$). The angle of PT exhibited a drop from 20.8 ± 7.9 to 15.7 ± 5.6, indicating statistically significant results ($p < 0.050$). Therefore, the findings of this study demonstrate the efficacy of micro-discectomy in ameliorating sagittal imbalance among body builders diagnosed with LDH following surgical intervention. This study has also yielded valuable insights into the sports' health implications for enhancing the overall performance of body builders. It has achieved this by implementing diverse rehabilitation protocols and ensuring the long-term monitoring of athletes with LDH who are undergoing treatment.

KEYWORDS: Micro-Discectomy, Lower Lumbar, Sagittal Vertical Axis, Sagittal Balance, Body Builders, Sports Health

1. INTRODUCTION

The physical demands of body building practices impose significant strain on the spinal column, making herniated discs a prevalent injury among body builders. This injury occurs when a spinal disc protrudes or ruptures, causing increased pressure on the nerves that pass through the spinal column (Aziz & Hanifah, 2019). This condition significantly impairs the body builder's performance due to the resulting discomfort and pain. Lumbar disc herniation (LDH) is prevalent among body builders. Body builders with LDH often demonstrate true sportsmanship by continuing to play for the success of their teams in numerous instances. However, individuals may encounter significant difficulties in this regard because of the presence of pain and discomfort (Zeng, 2003). Consequently, the heightened stress and pressure on other body parts of the body builders can lead to an increased risk of additional injuries. It is found that 48% of athletes and sportsmen in Turkey have a higher susceptibility to LDH. Therefore, athletes and body builders employ various conservative treatments, such as compression garments or supportive braces. This intervention aids in reducing nerve pressure and promoting spinal stability (Shimony et al., 2021). Many Turkish body builders with LDH often demonstrate true sportsmanship by continuing to exercise for the success of their teams in numerous instances. Body builders with LDH undergo chiropractic treatment or physical therapy to alleviate pain, improve mobility, and enhance muscle strength. Sports health organisations are primarily advocating for the use of these therapies to treat body builders with LDH (Young, 2006). In certain instances, sports health organisations occasionally employ epidural injection (Rao, Narnaware, & Giripunje, 2023).The global prevalence of lumbar

degenerative spine disease is 3.63%. Furthermore, this condition is found to be four times more prevalent in low- and middle-income countries compared to high-income countries. This condition exhibits higher prevalence rates among body builders. Body builders may choose to continue strength training and other resistance-based exercises, while managing symptoms of LDH, with some opting for surgery to achieve a complete recovery. Surgeons employ various techniques for treating lumbar disc herniation (LDH), including spinal fusion surgery (SFS), microdiscectomy, and other procedures. SFS refers to the fusion of two or more vertebrae in the spine, resulting in reduced nerve pressure and increased spinal stability. The recovery period for this surgical procedure is longer compared to a discectomy. Moreover, the treatment of disc herniation has undergone significant changes due to advancements in technology. Lumbar Microdiscectomy (LM) is currently considered the preferred surgical treatment for Lumbar Disc Herniation (LDH) due to its minimally invasive nature and reduced impact on the body (Dowling & Munakomi, 2023). The LM procedure is a minimally invasive surgical technique that uses a microscope or surgical glasses called loupes. It is characterised by its small incisions and low invasiveness. Loupes are used for the purpose of magnifying the area of interest.

In addition, smaller surgical instruments are used to perform the procedure within a limited spinal area. Many body builders with LDH may need to undergo LM following a conservative procedure. If conservative treatment is ineffective, surgical intervention is considered (Lagerbäck et al., 2019).There is a lack of research on the effects of the LM procedure on the sagittal vertical axis (SVA) and sagittal balance in body builders, specifically at the lower lumbar levels. This study aims to address the existing gap in research by examining 109 body builders in Turkey. This study aims to analyse the disparities in SVA and sagittal balance following the LM procedure. This study is significant because it examines the clinical relevance of the LM procedure in body builders. It specifically investigates its impact on sagittal balance and the SVA, with implications for sports health. Additionally, this study offers valuable insights into the effects of LM on body builders with LDH in the relatively unexplored Turkish context.

2. Literature Review

2.1 Treatment Types for LDH

The presence of Modic changes in the spine of patients with lumbar disc herniation prior to microdiscectomy is associated with inferior outcomes. These adverse effects encompass heightened back pain, diminished capacity to carry out everyday activities (lower functional scores) and decreased post-surgical satisfaction. The presence of Modic changes prior to surgery indicates a more difficult recovery and lower satisfaction with the surgical outcomes. Early-stage

minimally invasive lumbar microdiscectomy surgery may offer functional advantages for patients (Ahn & Chon, 2018). In summary, an earlier surgical intervention for individuals with lumbar disc issues may yield superior outcomes and enhanced functionality. The primary technique for treating lumbar disc herniation is lumbar microdiscectomy. Researchers have observed a significant correlation between gender and the levels of Tuffier's line in cases involving lumbar microdiscectomy. This evidence suggests that gender influences Tuffier's line levels in individuals who undergo lumbar microdiscectomy procedures (Ali &Malçok). A higher spinocranial angle may be associated with poorer preoperative outcomes but improved postoperative correction. Researchers can use this angle as a novel standard to evaluate sagittal balance in the cervical spine and assess the quality of life of patients(Wang et al., 2021). The preoperative cervical sagittal balance indexes are associated with the postoperative outcomes of patients with OPLL who undergo laminoplasty. People who had high levels of CGH-C7 in their sagittal vertical axis before surgery are more likely to develop sagittal imbalances and neurological symptoms in their cervical spine. This measurement can be a reliable predictor of laminoplasty outcomes in patients with cervical OPLL (Larsson & Karlefors, 2015; Xu et al., 2020). Patients with Hirayama disease display an abnormal sagittal alignment of the cervical spine in comparison to their healthy peers of similar age. Surgical intervention can rectify sagittal imbalance. Individuals with Hirayama disease showed better postoperative outcomes when they had a larger Cobb angle and a decreased CGH-C7 SVA. Surgeons can use these factors as predictive indicators for surgical outcomes, providing valuable insights for preoperative assessment(Lu et al., 2021).

2.2 LDH Treatment and Sports Health

Different sports like football, body building and basketball can cause physical strain on players, resulting in increased pressure on their nerves and spinal cord. This can lead to various health problems. LDH is one of the issues that can be discussed. This condition primarily affects body builders who engage in rigorous physical training and exercise regimens. It is important for sports organisations and other stakeholders to prioritise the health of athletes. It is reported that 75% increase in the prevalence of LDH among athletes, involved in body building and strength training. The return to play (RTP) for elite athletes is a significant concern in relation to both conservative and operative treatments. The rate of recovery is also a factor to be considered. Microdiscectomy is a commonly employed treatment for athletes and body builders with lumbar disc herniation (LDH) (Zinn, Wood, Williden, Chatterton, & Maunder, 2017). Microdiscectomy has statistically significant effects on the sagittal vertical axis and sagittal balance in the lower back. However, these effects may not have practical significance in real-world situations. It is discovered that statistically significant but small change in the position of the spine's central line, which shifted approximately 9.6 millimetres, and the pelvic

tilt, which adjusted by 1.6 degrees after the surgical procedure. These changes, however, are unlikely to significantly impact an individual's overall spinal alignment or balance. Numerous sports medicine and health organisations endorse this treatment for athletes and body builders with LDH (Zhou & Liu, 2022). This study provides valuable insights into the impact of microdiscectomy on the sagittal vertical axis and sagittal balance in the lower lumbar region among body builders, contributing to the existing body of research in this area. This study provides a comprehensive analysis of the outcomes and changes in spinal alignment that occur after the procedure. These findings contribute to the understanding of lower back surgical interventions and their effects on spinal balance in body builders, thereby enhancing the knowledge of relevant sports organisations in this area. These insights are crucial for sports healthcare professionals as they assist in making informed decisions and achieving optimal outcomes for body builders who undergo microdiscectomy in the lower lumbar region.

3. Method

Konya Education ve Research Hospital diagnosed lumbar disc herniation (LDH) in 102 body builders between January 2019 and December 2019. Out of the total, 25 body builders initially exhibited spinal sagittal imbalance. The sample consisted of 81 males and 21 females, with an average age of 37.4 years (ranging from 25 to 55 years). Due to the lack of a standardised criterion for defining sagittal imbalance, we chose to incorporate the symptom with a radiographic parameter. The coach directed the body builders to stand and move forward while bending their bodies. The selected radiographic standard was to measure the horizontal distance between the C7 plumb line and the posterior superior corner of S1, referred to as SVA. In our study, we classified a horizontal distance of more than 5 cm in the anterior or posterior direction between C7PL and S1 SVA as a sign of sagittal imbalance. In this study, we defined distances greater than 5 cm in the anterior direction as indicative of sagittal imbalance.

3.1 Inclusion Criteria

1. For this study, only body builders aged from 25 to 55 were included in the study. 2. Body builders who were diagnosed with lumbar disc herniation (LDH) was included in this study. 3. Body builders with a horizontal difference between the C7 plumb line and S1 greater than 5 cm anteriorly at the time of initial spinal sagittal imbalance, were included. 4. Body builders who have attempted more than three months of typical conservative therapies without results, such as bed rest, physical therapy, nonsteroidal medicines, and lifestyle changes, were included. 5. Body builders who have disc herniation at the L1-2, L3-4, L4-L5, or L5-S1 levels, were included. 6. Body builders who were able to stand or stroll until they were briefly unable to stand straight, were included in

this study.

3.2 Exclusion Criteria

Participants having these conditions were not selected for the study: 1. Body builders suffering from neuromuscular illnesses. 2. Ankylosing spondylitis patients. 3. Those who suffer from flat-back syndrome. 4. Body builders who have a history of hip, pelvic, or lower limb problems or who exhibit clinical symptoms. 5. Body builders who have previously had spinal surgery. 6. Body builders with malignancies, metabolic bone disorders, infections, or spinal compression fractures. 7. Body builders with multiple-level herniated lumbar discs.

3.3 Radiographic Measurements

The radiographic measurements used to evaluate sagittal alignment balance consist of pelvis incidence (PI), pelvis tilt (PT), sacral slope (SS) for the pelvis, and sagittal vertical axis (SVA), thoracic kyphosis (TK), and lumbar lordosis (LL) for the spine. Trunk shift (TS) is the sole parameter used to assess balance in the coronal alignment.

3.4 Back Muscle Strength Measurement

EMG was employed to assess the maximal voluntary contraction of the paraspinal muscles in the participants. Prior to electrode placement, excess body hair was removed, and the skin was cleansed using alcohol and water swabs. Disposable surface adhesive electrodes were placed on the NIHON KOHDEN 9200 EMG apparatus at the thoracic, thoracolumbar, and herniated disc levels. The researchers collected EMG data using a set of bipolar standard surface adhesive electrodes composed of Ag/AgCl. The body builders who were chosen underwent surgery and were subsequently mobilised in a gradual manner. The hospital discharged them approximately 7 to 10 days after the surgery. The use of a lumbosacral corset was necessary for walking. We obtained post-operative EMG measurements without exercising the waist musculi dorsi function. The researchers presented the ODI results as percentages, ranging from 0% to 100%. A score of 0% indicated the absence of pain or disability, while a score of 100% indicated the presence of the most severe pain and disability.

3.5 Statistical Analysis

The statistical analysis was conducted using SPSS 22.2 software. *p* values were calculated using a paired t-test performed by the student to compare preoperative and postoperative measurements. The statistical outcomes varied when p-values were less than 0.05.

4. Results

4.1 Demographics of Participants

Table 1 presents the demographic characteristics of the participants. The average age of the chosen body builders was 37.4 years. Out of the 102 participants, 21 were female, accounting for 20.5% of the total, while 81 were male, representing 79.4% of the total. The average duration of follow-up for the participants was 29.6 months. The preoperative mean oxygen desaturation index (ODI) was 77.9%, which significantly decreased to 4.3% postoperatively.

Table 1: Demographics of participants

FACTORS	N (MEAN)	%
AGE (YEARS)	37.4	
GENDER		
FEMALE	21	20.5
MALE	81	79.4
MEAN FOLLOW-UP TIME (MONTHS)	29.6	
ODI (BEFORE SURGERY)	77.9%	
ODI (AFTER SURGERY)	4.3%	

4.2 Parameters of Spino-Pelvic Alignment

Table 2 presents the parameters used to assess sagittal balance in body builders within the context of spino-pelvic alignment (SPA). The parameters of the pelvis encompass sacral slope, pelvis incidence, and pelvis tilt. The parameters considered for the spine were thoracic kyphosis, sagittal vertical axis, and lumbar lordosis. Trunk shift was the sole parameter considered for achieving balance in the coronal alignment.

Table 2(a): SPA parameters

PARAMETERS	DESCRIPTIONS
SAGITTAL VERTICAL AXIS-C7PLUMBLINE (CM)- (SVA-C7PL)	It is the horizontal distance between the plumb line (C7) and the sacrum's posterior corner.
TRUNKSHIFT(CM) (TS)	It is the horizontal distance between the vertical line of center sacral and plumb line (C7).
LUMBARLORDOSIS (LL) (°)	It is the cobb angle between S1 and L1.
THORACICKYPHOSIS (TK) (°)	It is the cobb angle between T12 and T5.
PELVICTILT (PT) (°)	It is the angle present between the line which connects the sacral plate's midpoint to the vertical plane as well as the bicoxofemoral axis.

Table 2(b): SPA parameters

PARAMETERS	DESCRIPTIONS
PELVICINCIDENCE (PI) (°)	It is the angle between the sacral plate's perpendicular line and the line which connects the sacral plate's midpoint to bicoxofemoral axis.
SACRALSLOPE (SS) (°)	It is the slope angle between the horizontal line and the S1 (superior endplate).

A comparative analysis was conducted to gain a better understanding of the treatment of body builders with LDH. This analysis involved determining the spinopelvic parameters before and after surgery. A statistically significant difference was found in the SVA between pre-operation (11.7 ± 6.7) and post-operation (0.51 ± 2.7), with a p-value of less than 0.050. Both the parameters of the pelvic region and the spine exhibited significant results. The angle of TK decreased significantly from 24.8 ± 11.4 to 22.1 ± 9.7 before and after the surgery ($p < 0.050$). The angle of LL significantly improved from 25.4 ± 14.1 to 42.5 ± 10.4 after the operation ($p < 0.050$). The average angle of SS showed a significant increase from 25.7 ± 9.6 to 30.41 ± 8.8 following the surgical procedure ($p < 0.050$). The angle of PT decreased significantly from 20.8 ± 7.9 to 15.7 ± 5.6 ($p < 0.050$).

Table 3: Pre- and post-operative comparison between parameters of spinopelvic

PARAMETER	PRE-OP	POST-OP	*P*
C7PL-SVA (CM)	11.7±6.7	0.51±2.7	< 0.050
SS (°)	25.7±9.6	30.41±8.8	< 0.050
LL (°)	25.4±14.1	42.5±10.4	< 0.050
TK (°)	24.8±11.4	22.1±9.7	< 0.050
PT (°)	20.8±7.9	15.7±5.6	< 0.050
PI (°)	46.4±11.7	46.4±11.7	–
TS (CM)	2.8±6.3	0.3±0.6	< 0.050

Op= operative

4.4 Largest Orders of Recruitment Comparison

Before the surgical intervention, Table 4 indicated that the recruitment potential of the spinal musculature at the herniated level was smaller than the other two levels for the body builders under study. After the surgical procedure, we observed significant differences in the recruitment of the major potentials within the spinal musculature across all three levels. The observed values of T7 to T8 exhibited a notable alteration from 0.42 ± 0.25 to 0.75 ± 0.33 after the operation. This change in values is indicative of significant outcomes, as evidenced by a p-value less than 0.050. The T12 to L1 region showed comparable findings, with recorded values of 0.47 ± 0.22 (preoperative) and

0.74 ± 0.18 (postoperative). In the case of the L4 to L5 region, the observed values exhibited a range of 0.33 ± 0.18 to 0.96 ± 0.32. These findings are considered statistically significant, as the p-value was found to be less than 0.05.

Table 4: Largest Orders of Recruitment Comparison

LARGEST ORDER OF RECRUITMENT(MV)	T7 TO T8	T12 TO L1	L4 TO L5*
BEFOREOP	0.42±0.25	0.47±0.22	0.33±0.18
AFTEROP	0.75±0.33	0.74±0.18	0.96±0.32
P	< 0.050	< 0.050	< 0.050

Moreover, it has been noted that the herniated level exhibits the highest recruitment potential compared to the other two levels. Therefore, the alterations in electromyography (EMG) and radiographic parameters are depicted in Figure 1, pertaining to the third body builder examined in this study.

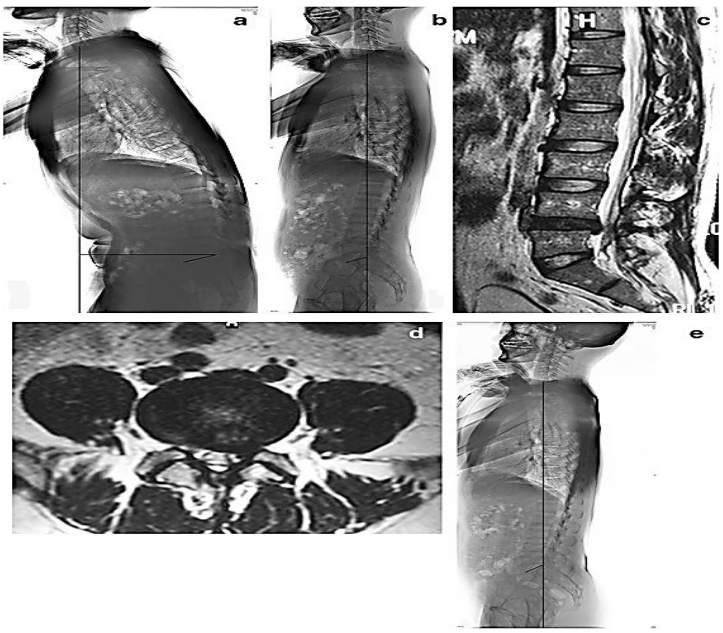

Figure 1: 36-year-old body builder with disc herniation (L4/ 5) (patient no. 3). (a) represents a lateral radiograph before operation, showing the sagittal imbalance (SVA= 18.4 cm). (b) radiograph immediately after the operation, showing sagittal balance which is restored. (c) and (d) MRI showing disc herniation (L4/ 5) with impingement of nerve root (left L5). (e) radiograph after 2.5 years of operation, presenting sagittal balance (SVA= 0.6 cm)

Consequently, the findings derived from this investigation demonstrate that lumbar discectomy plays a significant role in ameliorating sagittal imbalance among body builders, enhancing their overall postural alignment, and providing spinal stabilisation. Body builders with lumbar disc herniation (LDH) have observed the efficacy of this surgical technique. The present study has demonstrated efficacy in elucidating both theoretical and practical

implications within the domain of sports health, specifically concentrating on body builders afflicted with LDH. Therefore, it is imperative for body builders of all age groups and genders to prioritise the well-being of their spinal column, by implementing essential measures aimed at averting lumbar disc herniation (LDH) in subsequent periods. To enhance their overall strength performance, body builders may employ various strategies, such as engaging in strength training, maintaining proper posture, and participating in regular exercise.

5. Discussion

In the realm of sports, body builders are subject to an elevated susceptibility to lumbar disc herniation (LDH). Multiple factors, such as reduced muscle strength, degeneration of adjacent discs, and disorders affecting the hip and pelvic regions, influence sagittal imbalance. These factors collectively hinder the patient's ability to compensate, potentially leading to increased disability. This study examines the impact of microdiscectomy on the sagittal vertical axis and sagittal balance in a cohort of 102 Turkish body builders. The primary objective is to investigate the implications for sports health in this specific context. Following surgery on a group of body builders, this study showed significant improvements in the anterior translation of the C7 plumb line. These improvements were accompanied by the restoration of lumbar lordosis, thoracic kyphosis, and sacral slope. Significantly, there was a notable increase in the recruitment potential of the spinal musculature across all three levels after the surgical intervention. Furthermore, after the surgical procedure, all participants reported a reduction in pain and a significant improvement in their overall quality of life. Heightened physical activity in body building results in a decrease in trunk muscle strength, specifically extensor strength, which influences spinal sagittal imbalance associated with lumbar disc herniation (LDH). The transforaminal percutaneous approach was used for all surgical procedures, preserving the inherent characteristics of the trunk muscles both before and after the operation. Individuals with lumbar disc herniation (LDH) may have weak muscles because they are experiencing both dorsalgia and radiculopathy at the same time. This makes it difficult for them to participate in sports. Back and sciatic pain limit muscle activity, ultimately contributing to spinal sagittal imbalance and underscoring the association between pain and muscular weakness. The observations underscore the notion that sagittal imbalance is predominantly a compensatory reaction rather than a structural aberration. A thorough understanding of the fundamental mechanisms is of great importance for surgeons in devising optimal management strategies during surgical planning. It is worth noting that certain individuals who exhibit sagittal imbalance on X-rays may remain asymptomatic for prolonged durations until they unexpectedly manifest symptoms related to the imbalance. Instances of such occurrences frequently align with the presence of profound degenerative lumbar conditions, in which the compression of the lumbosacral nerve roots plays a substantial role in the advancement of sagittal imbalance

(Bourret et al., 2022). A thorough understanding of the fundamental mechanisms is of great importance for surgeons in devising optimal management strategies during surgical planning. It is worth noting that certain individuals who exhibit sagittal imbalance on X-rays may remain asymptomatic for prolonged durations until they unexpectedly manifest symptoms related to the imbalance. When these kinds of things happen, they often happen along with severe degenerative lumbar conditions. In these cases, the compression of the lumbosacral nerve roots is a major cause of the progression of sagittal imbalance. Various factors including age, gender, body weight, and ethnicity influence the inherent uniqueness of sagittal spinal morphology among individuals. These factors contribute to the observed variations in sagittal spinal morphology across different individuals. As a result, it can be observed that there is a lack of a standardised sagittal balance among the general population. Therefore, the present study chose to employ identical body builders as their own control group prior to and following the surgical intervention, thereby contributing to the understanding of sports-related health implications within this domain. It is conducted that thorough examination of compensatory mechanisms linked to sagittal imbalance. In their study, the authors introduced a three-step algorithm aimed at evaluating the equilibrium status, with a specific focus on three commonly observed compensatory mechanisms. The procedure encompassed the quantification of pelvic incidence (PI), assessment of global sagittal alignment by means of C7 positioning, and identification of compensatory mechanisms such as retrolisthesis, knee flexion, and insufficient pelvic tilt (PT) to PI ratio (Korez, Putzier, & Vrtovec, 2020). The findings of our study demonstrate strong concordance with the proposed conceptual framework. The previous literature has established the importance of knee flexion as a compensatory mechanism in the lower extremities. Considering this, our study aimed to investigate the efficacy of instructing body builders to achieve full knee extension in order to accurately assess the degree of imbalance. The present study has demonstrated the efficacy of this approach in enhancing the overall posture and sports performance of the participants involved.

6. Conclusion

Compensatory sagittal imbalance, specifically lumbar disc herniation (LDH), frequently manifests in body builders who engage in rigorous physical exertion, thereby exerting a detrimental influence on their overall performance. The principal compensatory mechanisms that contribute to sagittal imbalance of the spine in body builders encompass a decrease in lumbar lordosis, an augmentation in thoracic kyphosis, and an alteration in pelvic tilt. The muscles of the trunk are of significant importance in the maintenance of the sagittal and coronal balance of the spine. There is a notable potential for automated rectification of sagittal imbalance when opting for an early posterior discectomy. Implementing this particular methodology can alleviate the pressure exerted on

the affected intervertebral disc. This, in turn, facilitates the inherent realignment of the spinal column and reinstates the equilibrium of the human body. As a result, the individuals involved experience an enhancement in their overall physical capabilities and strength performance. The musculature of the trunk plays a crucial role in upholding the sagittal and coronal equilibrium of the spinal column. The early implementation of a posterior discectomy presents a significant opportunity for the automated correction of sagittal imbalance. This specific methodology can mitigate the pressure exerted on the affected intervertebral disc. Consequently, this process enables the natural readjustment of the vertebral column and restores the balance of the human body. Therefore, the individuals engaged in the activity undergo an augmentation in their comprehensive physical capacities and athletic aptitude.

7. Implications

This study elucidates the compensatory mechanisms involved in spinal sagittal imbalance, emphasising the important roles of muscle mass, pelvic position, and spinal alignment. This knowledge aids in developing theoretical frameworks that elucidate the complex interaction among various factors influencing spinal balance. This study highlights the significance of pain management in improving muscle strength and spinal balance. It emphasises the relationship between back and sciatic pain and muscular weakness. The relationship between pain and musculoskeletal function is now well-established due to advancements in theoretical understanding. This study has contributed valuable insights to sports organisations and other stakeholders regarding the impact of LDH on the athletic performance of body builders. Efforts have been made to prioritise the integration of effective sports health implications for these body builders. The findings of this research can inform surgeons in developing more effective surgical strategies for addressing sagittal imbalance caused by lumbar disc herniation (LDH) in body builders. Practitioners in sports medicine/health organisations can enhance pain management and rehabilitation protocols by considering the interplay between pain, muscular weakness, and spinal instability. Specialised rehabilitation programmes may be implemented to enhance trunk muscle strength and flexibility in body builders. Sports healthcare professionals can now adopt a patient-specific treatment approach, taking into consideration the variations in sagittal spinal morphology among individuals. By acknowledging the individuality of each patient's spinal balance, healthcare providers can enhance the personalisation of treatment regimens, considering specific factors such as age, sex, weight, and ethnicity.

8. Limitation and Future Recommendations

The study's limitations include a small sample size and a lack of diversity among participants, potentially limiting the generalizability of the results to larger populations. The study primarily focused on body builders with LDH in

Turkey. The absence of long-term follow-up data may limit the ability to accurately assess the enduring advantages of the surgical procedure or the stability of observed changes in sagittal imbalance among body builders. This study primarily examines the impact of variables such as muscle strength and spinal alignment on the sports performance of body builders with LDH. Excluded from consideration were lifestyle choices, medical conditions, and psychological factors that may impact the spinal-sagittal imbalance of body builders. Longitudinal studies tracking patients over an extended duration may provide valuable insights for future research on the enduring impact of surgical intervention on spinal sagittal imbalance. These studies would assess factors such as recurrence rates and long-term functional outcomes. A comprehensive patient assessment that considers psychological, behavioural, and environmental factors may enhance our understanding of the multidimensional nature of spinal sagittal imbalance and its impact on treatment outcomes. Comparison studies between different surgical procedures or rehabilitation regimens can provide valuable insights into the most effective and durable approaches for treating sagittal imbalance. These studies have the potential to inform evidence-based clinical practices in this area. Advanced imaging techniques, such as 3D modelling or dynamic imaging, can provide a deeper understanding of biomechanical changes. This approach can also effectively improve the RTP of athletes who undergo microdiscectomy treatment.

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