

# Assessment of Isokinetic Trunk Muscle Strength and its Association with Health- Related Quality of Life in Patients with Degenerative Spinal Deformity

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## Research article

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## Abstract

**Background:** A considerable portion of the elderly population are increasingly afflicted by degenerative spinal deformity (DSD), which seriously affects patient health-related quality of life (HQOL). This index is used across many studies to show correlations between radio-graphical alignment, disability, and pain in patients with DSD. However, imaged structural deformity represents only one aspect for consideration, namely, the disability effect of DSD. We assessed the isokinetic strength of trunk muscle in patients with degenerative spinal deformity (DSD), and investigated its relationship with health-related quality of life (HQOL).

**Methods:** In total, 38 patients with DSD (DSD group) and 32 healthy individuals (control group) were recruited. Both groups were homogeneous for age, weight, height and body mass index (BMI). Assessments were performed using the isokinetic dynamometer IsoMed-2000; trunk extensor, flexor strength and flexion/extension (F/E) ratios were explored concentrically at speeds of 30°, 60° and 120° per second. The grip strength of both hands was measured using a hand-held dynamometer. Visual analogue scale (VAS) scores, the Oswestry Disability Index (ODI), a Roland-Morris disability questionnaire (RDQ), and a 36-item Short Form Health Survey (SF-36) evaluated patient HQOL. Correlations between trunk strength and HQOL were analyzed.

**Results:** When compared with the control group, the DSD group showed lower trunk extensor strength at three velocity movements, and higher F/E ratios at 60° and 120°/s ( $p < 0.05$ ). Both groups exhibited similar trunk flexor strength and grip strength ( $p > 0.05$ ). In DSD group, trunk extensor strength at 60°/s was negatively associated with ODI and RDQ ( $p < 0.05$ ). A negative relationship between trunk flexor strength at 120°/s and ODI was also recorded ( $p < 0.05$ ). In addition, trunk extensor strength at 60°/s and trunk flexor strength at 120°/s were positively correlated with physical functioning and role-physical scores according to the SF-36 ( $p < 0.05$ ).

**Conclusions:** We identified isolated trunk extensor myopathy in DSD, which causes an imbalance in trunk muscle strength. Isokinetic trunk extensor strength at 60°/s and trunk flexor strength at 120°/s can predict disability, and decrease physical HQOL in DSD patients.

## Background

A considerable portion of the elderly population are increasingly afflicted by degenerative spinal deformity (DSD), thanks to aging populations and demographic shifts. Due to spinal stenosis, DSD often leads to radiculopathy and low back pain, which seriously affects patient health-related quality of life (HQOL) [1]. This index is used across many studies to show correlations between radio-graphical alignment, disability, and pain in patients with DSD [2, 3, 4]. However, imaged structural deformity represents only one aspect for consideration, namely, the disability effect of DSD.

Recent evidence has revealed that increased fat infiltration and decreased muscle volumes in trunk muscles are associated with sagittal malalignment/sagittal plane malalignment in DSD patients [3, 6], suggesting that trunk muscle dysfunction is related to DSD. Trunk muscles control balance and posture, which are essential for normal functional activities, e.g. walking [7]. Because muscle strength is an important aspect of physical performance and functional assessment, previous studies have uncovered associations between trunk extensor muscles and HQOL in low back pain (LBP) patients [8,9,10]. However, as we know, it had been performed to evaluate the impact of trunk muscle strength of DSD patients on HQOL in few studies.

Isokinetic dynamometry is an effective and reliable device that measures torque forces produced by specific action muscle groups [11]. Studies have focused on the isokinetic assessment of trunk muscle functions in healthy subjects [12] and LBP subjects [10], while those on trunk muscle strength assessments in DSD patients are rare. Although trunk muscle mass deteriorates with age, and is sensitive to pathological factors [13], specific changes in trunk muscle strength and their effects on DSD are unclear.

Therefore, we studied isokinetic trunk muscle strength in DSD patients, and compared the data with healthy controls. We also studied correlations between these variables and HQOL in DSD patients.

## Methods

### Participants

This prospective cross-sectional study consisted of 38 DSD patients (DSD group) recruited from March 2018 to November 2019, at a single hospital facility. The inclusion criteria were: (1) aged > 45 years, (2) Cobb angle > 10° or sagittal vertical axis (SVA) > 5 cm, (3)

no associated idiopathic, congenital, developmental or neuromuscular spinal abnormalities and no history of spinal surgery, (4) no serious back pain that could affect maximum force assessments. Thirty two healthy subjects, without degenerative lumbar diseases and > 45 years were recruited from the community during the same period. Volunteers “Healthy controls and DSD patients” were excluded if they had previously received physical therapy, acupuncture, or back strength training. Patient demographics were recorded; sex, age, height, weight and body mass index (BMI). The study was approved by the Ethical Committee of the First Affiliated Hospital, Third Military Medical University, PLA “People’s Liberation Army” (approval number; KY201853). Informed consent was sought from all participants prior to assessments, and all research activities were in accordance with the principles of the Declaration of Helsinki.

### **Isokinetic trunk muscle strength assessments**

The trunk muscle strength of all subjects, in a seated position, was measured by isokinetic dynamometer IsoMed 2000 (D&R Technology GmbH Inc, Frankfurt am Main, Germany). Test positions and procedures followed Roth *et al.* recommendations [14]. The tested range of motion (ROM) was set to cover 40° depending on the movement of the lever arm. Concentric exploration of trunk flexors and extensors in three series’ of five consecutive bending-extension movements were performed at speeds of 30°/s, 60°/s and 120°/s [15]. Participants warmed up 20 to 30 minutes on a cycle ergometer before testing. Once positioned, and after familiarizing themselves with one or two submaximal practices, each participant completed five consecutive repetitions in isokinetic mode, starting with an upright position, and followed by a trunk extension scan from -20° to 20° (Figure 1 A–C). Participants were asked to extend to the maximum extension. Verbal encouragements was provided throughout the program to encourage maximum effort. The PT (peak torque) of trunk extensor, flexor and F/E ratios were recorded for each series. Rest times between each series was one minute.

### **Grip strength evaluation**

We used a digital dynamometer (CAMRY EH101; Hengqi, Guangdong, China) to assess grip strength. In a standard procedure recommended by the American Association of Hand Therapists, participants sat with their elbows bent at 90° holding a dynamometer, with the meter indicator facing outward, away from the body [16]. Participants held the meter firmly for at least two seconds. One practice test was performed with each hand, and then alternated three times between hands, always starting with the dominant hand. Participants were given verbal encouragement to ensure maximum effort. Maximal values were recorded on the display of the instrument.

### **Health-related quality of life assessment**

We used visual analogue scale (VAS) scores to evaluate the degree of LBP [17]. The VAS score scale ranged from 0–10, the higher the score, the greater the pain intensity. Dysfunction was assessed by the Oswestry Disability Index (ODI) and Roland-Morris Disability Questionnaires (RDQ). ODI scales ranged from 0–100%, with a higher ODI indicating more severe dysfunction [18]. RDQ scores ranged from 0 (no disability) to 24 (severe disability) [19]. The 36-item Short Form Health Survey (SF-36) evaluated general quality of life [20], and included nine subscales, comprising; physical functioning (PF), role physical (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role emotional (RE), mental health (MH) and health transition (HT). Scores were directly converted to a 0–100 point range. Total SF-36 scores ranged from 0–900, the higher the score, the better the physical condition.

### **Statistical analyses**

All data were expressed as the mean plus standard deviation (SD). Differences between DSD and healthy groups were determined by an independent sample T-test. Comparisons of gender distribution between groups was performed by the Chi-square test. The difference degree (Diff %) of trunk muscle strength between groups was measured using the following formula:  $\text{Diff \%} = (\text{high value} - \text{low value}) / \text{high value} \times 100\%$ . To explain changes in HQOL in terms of changes in trunk muscle strength, the determination coefficient, R<sup>2</sup> was adopted as an evaluation index. The closer R<sup>2</sup> was to 1, the closer the relationship between them. We used Pearson’s correlation coefficients to assess correlations between all evaluated variables. Statistical significance was determined at  $p < 0.05$ , using SPSS statistical software, version 20.0 (SPSS Inc, Chicago, USA).

## **Results**

## General information

The mean demographic characteristics of both groups are shown (Table 1). There were no significant differences between groups ( $p > 0.05$ ). In the DSD group, there were 23 cases of degenerative scoliosis, five of degenerative kyphosis and 10 of degenerative scoliosis-kyphosis.

Table 1  
Demographic characteristics of both groups(mean  $\pm$  SD)

| Variable   | DSD group       | Control group   | Statistics       | P value |
|--|-----------------|-----------------|------------------|---------|
| Cases  | 38              | 32              | -                | -       |
| Male/female  | 8/30            | 4/28            | $\chi^2 = 0.394$ | 0.530   |
| Age (years)  | 63.8 $\pm$ 8.0  | 60.8 $\pm$ 6.8  | t = 1.675        | 0.098   |
| Height(cm)   | 153.4 $\pm$ 7.6 | 153.7 $\pm$ 6.9 | t = -0.208       | 0.836   |
| Weight(kg)   | 57.3 $\pm$ 7.6  | 57.0 $\pm$ 6.2  | t = 0.158        | 0.875   |
| BMI (kg/m <sup>2</sup> )   | 24.3 $\pm$ 2.4  | 24.2 $\pm$ 2.9  | t = 0.210        | 0.835   |
| Abbreviations: SD, Standard deviation; DSD, Degenerative spinal deformity ; BMI, Body mass index |                 |                 |                  |         |

## Differences Between Groups

Trunk extensor PT values at three velocities were significantly lower in the DSD group, when compared with the control group ( $p < 0.05$ ). Both groups exhibited similar trunk flexor PT values and grip strength in both hands ( $p > 0.05$ ). In addition, F/E at 60°/s and 120°/s speeds in the DSD group were significantly higher than the control group ( $p < 0.05$ ). Differences in trunk extensor PT and F/E degrees between groups were greatest when the velocity was 60°/s (Table 2). The velocity-changing trend diagram of isokinetic strength of trunk muscle showed that both trunk flexor and extensor PT in the control group were always higher than the DSD group, the trends of flexor PT growth of both groups were basically the same and the extensor PT in control group also maintained an increasing trend, while there is a mild downturn for extensor PT from the speed of 30°/s to 60°/s in DSD group (Fig. 2A). The F/E ratio of trunk PT in the DSD group was always greater than 1 and kept increasing, while the F/E ratio was approximately 1 and remained relatively stable in the control group (Fig. 2B).

Table 2  
Trunk muscle strength and grip strength of both Groups (mean  $\pm$  SD)

| Characteristic  | 30°/s           |                   |               | 60°/s           |                   |               | 120°/s           |                   |               | GS-left(Kg)    | GS-right(Kg)   |
|---|-----------------|-------------------|---------------|-----------------|-------------------|---------------|------------------|-------------------|---------------|----------------|----------------|
|   | Flexor PT (N·m) | Extensor PT (N·m) | F/E           | Flexor PT (N·m) | Extensor PT (N·m) | F/E           | Flexor PT (N·m)  | Extensor PT (N·m) | F/E           |                |                |
| DSD group   | 58.9 $\pm$ 36.3 | 64.3 $\pm$ 48.5   | 1.1 $\pm$ 0.6 | 68.7 $\pm$ 30.8 | 62.2 $\pm$ 39.1   | 1.4 $\pm$ 0.7 | 91.5 $\pm$ 45.9  | 73.6 $\pm$ 46.4   | 1.5 $\pm$ 0.8 | 24.4 $\pm$ 7.5 | 25.1 $\pm$ 8.3 |
| Control group   | 70.8 $\pm$ 24.4 | 91.3 $\pm$ 36.1   | 0.9 $\pm$ 0.4 | 76.6 $\pm$ 25.4 | 94.4 $\pm$ 40.2   | 0.9 $\pm$ 0.4 | 103.0 $\pm$ 40.5 | 105.5 $\pm$ 42.0  | 1.1 $\pm$ 0.5 | 25.5 $\pm$ 5.2 | 26.0 $\pm$ 4.9 |
| Diff %  | 16.8            | 29.6              | 22.2          | 10.3            | 34.1              | 55.6          | 11.2             | 30.2              | 36.4          | 4.3            | 3.5            |
| t   | -1.574          | -2.602            | 1.912         | -1.162          | -3.399            | 3.242         | -1.094           | -2.995            | 2.591         | -0.656         | -0.537         |
| P   | 0.120           | 0.011             | 0.061         | 0.249           | 0.001             | 0.002         | 0.278            | 0.004             | 0.012         | 0.514          | 0.593          |
| Abbreviations: SD, Standard deviation; DSD, Degenerative spinal deformity ; PT, Peak torque; Diff %, Between-group difference; F/E, Flexion/Extension ratio |                 |                   |               |                 |                   |               |                  |                   |               |                |                |

# Analysis Of Hqol Associated Factors

To minimize the impact of individual differences on the strength of the DSD patient's trunk muscles, PT was expressed relative to BW (body weight). Using Pearson correlation analysis, the PT/BW of trunk extensor at 60°/s was negatively associated with ODI and RDQ (R = -0.342 and -0.353, p < 0.05, respectively). A negative relationship was determined between the PT/BW of trunk flexor at 120°/s and ODI (R = -0.346, p < 0.05), but no significant correlations were observed between F/E ratios and HQOL (p > 0.05) (Table 3).

Table 3  
Correlation analysis ( adjusted body weight) between trunk muscle strength at different velocities and HQOL in DSD patients

| R   | VAS    | ODI     | RDQ     | SF-36  |
|---|--------|---------|---------|--------|
| 30°/s Flexor PT/ BW<br>(N·m·Kg <sup>-1</sup> )  | -0.109 | -0.129  | -0.205  | 0.091  |
| 30°/s Extensor PT/ BW<br>(N·m·Kg <sup>-1</sup> )  | -0.115 | -0.176  | -0.240  | 0.121  |
| 30°/s F/E   | -0.131 | 0.009   | 0.126   | -0.067 |
| 60°/s Flexor PT/ BW<br>(N·m·Kg <sup>-1</sup> )  | -0.099 | -0.281  | -0.279  | 0.135  |
| 60°/s Extensor PT/ BW<br>(N·m·Kg <sup>-1</sup> )  | -0.111 | -0.342* | -0.353* | 0.161  |
| 60°/s F/E   | -0.012 | -0.012  | 0.047   | -0.058 |
| 120°/s Flexor PT/ BW<br>(N·m·Kg <sup>-1</sup> )   | -0.164 | -0.346* | -0.271  | 0.140  |
| 120°/s Extensor PT/ BW<br>(N·m·Kg <sup>-1</sup> )   | -0.023 | -0.145  | -0.189  | 0.058  |
| 120°/s F/E  | -0.094 | -0.137  | 0.010   | -0.013 |
| Abbreviations: SD, Standard deviation; DSD, Degenerative spinal deformity; PT, Peak torque; BW, Body weight; F/E, Flexion/Extension ratio; VAS, Visual analogue scale; ODI, Oswestry Disability Index; RDQ, Roland-Morris Disability Questionnaires; SF-36, 36-item Short Form Health Survey. |        |         |         |        |
| * P<0.05 ** P<0.01  |        |         |         |        |

According to correlation analyses between trunk muscle strength and subscale SF-36 scores in DSD patients, the PT/BW of trunk extensor at 60°/s was positively correlated with physical functioning (PF) and role physical (RP) scores (R = 0.392 and 0.347, p < 0.05, respectively). In determining coefficients, the scatter diagram suggested that in all SF-36 subscales, PF and RP were the two indices most affected by trunk extensor strength, especially at 60°/s (Fig. 3A). In addition, the PT/BW of trunk flexor at 60°/s was positively correlated with PF scores (R = 0.327, p < 0.05). We also observed significant correlations between the PT/BW of trunk flexor at 120°/s, and PF and RP scores (R = 0.362 and 0.323, p < 0.05, respectively). The determination coefficient scatter diagram also suggested that PF and RP were key influential indicators of trunk flexor strength at 120°/s (Fig. 3B).

## Discussion

DSD is a common cause of disability and pain in the elderly [1]. Previous studies have highlighted the importance of the sagittal spine for pain and patient quality of life [2,3,4]. This muscle system maintains posture balance, therefore we investigated key muscles involved in lumbar stabilization. Trunk muscles maintain normal arrangement and spine stability [6], and preliminary studies have investigated trunk muscles using histological analyses [21], electromyography [22], ultrasound [23], computed tomography

scanning [24] or magnetic resonance imaging [25]. However, trunk muscle strength in DSD patients is an unknown area. Several devices have been developed to assess trunk strength, however the isokinetic dynamometer (IKD) is the gold standard [26]. Trunk flexion and extension force tests are typically performed in the sagittal plane. Isokinetic trunk strength assessments in flexion and extension, using the IsoMed-2000 dynamometer, are highly reliable according to Ralf *et al.* [14], therefore IKD is ideal for assessing trunk strength in DSD patients.

Our study observed that the DSD group exhibited lower trunk extensor PT, at all three velocities, when compared with the control group, although both groups were undifferentiated in terms of general condition, suggesting the trunk extensor muscle was compromised. Trunk extensor muscle mainly comprises multifidus and erector spinae, which are sensitive to pathological changes [27]. Several studies have shown extensor muscle degeneration in DSD patients; Shafaq *et al.* demonstrated significant smaller cross-sectional areas of multifidus in patients with degenerative lumbar scoliosis (DLS), when compared to those with degenerative lumbar stenosis (LSS) [21]. Seung-Jae *et al.* [28] observed that fat infiltration of the multifidus and erector spinae muscles in degenerative lumbar kyphosis patients was significantly higher than in healthy controls. Since back muscle radiological parameters are one of the most valuable indices for predicting back muscle strength [29], it is reasonable to speculate that a decreased size and increased fatty infiltration of trunk extensor muscle, may be associated with decreased trunk extensor isokinetic strength. Additionally, skeletal muscles tend to suffer with 'disuse atrophy' with lower activity levels and reduced muscle strength requirements [30]. DSD patients are often reluctant to perform trunk extension and strength training due to back pain, resulting in 'disuse atrophy' of trunk extensor muscles, culminating in a decline in muscle fiber recruitment. Thus, the ability to generate muscle strength is reduced, resulting in weakness of the trunk extensor.

Our findings showed that both groups exhibited similar trunk flexor and grip strength, suggesting the trunk extensor muscle is impaired exclusively in DSD patients. Yaji *et al.* [6] observed that muscular degeneration of the trunk extensor in DLS patients while the muscle strength and volume of the other body parts were normal, indicating that local myopathy rather than total degenerative loss of skeletal muscle which was called sarcopenia. A similar observation was recorded in lumbar degenerative kyphosis (LDK) patients [25]. Our study confirmed and extended the previous studies through muscle strength level, although the cause and effect relationship is still controversial.

Trunk extensor and flexor muscles interact with each other to maintain biomechanical stability of the lumbar spine [31], therefore evaluating the balance of trunk flexor, extensor muscle strength, and F/E ratios is an important evaluation index [32]. Spinal muscle balance is beneficial for F/E ratios < 1 in terms of equilibrium [32]. In this study, the F/E ratio of the control group was 0.9–1.1, which was within the ratio range of a normal population, whereas the F/E ratio in the DSD group, at 30°/s, 60°/s and 120°/s, were 1.1, 1.4 and 1.5, respectively. In addition, we observed higher F/E ratios at 60°/s and 120°/s, when compared with the control group, suggesting an imbalance in trunk flexor and extensor muscle strength in DSD patients. Although the PT of trunk flexor and extensor muscles in the DSD group was always lower than the control group, only extensor PT exhibited significant differences between groups. Therefore, we propose that impairments in trunk extensor muscles causes an imbalance of trunk muscle strength in DSD patients, and this imbalance is identified at speeds of 60°/s and 120°/s (fast) in isokinetic assessments.

Regular training of trunk muscle, and good core strength are important for daily life and physical activities [33]. Therefore, it is important to clarify the impact of trunk muscle strength changes on the quality of life of DSD patients. A previous study revealed that maximal muscle strength was observed in patients with higher body weight [34], therefore we adopted relative PT ( $N \cdot m \cdot Kg^{-1}$ ) as the index, while accounting for body weight, to minimize the influence of individual differences on correlation analyses between trunk muscle strength and quality of life of DSD patients.

Our study revealed significant correlations between trunk extensor PT at 60°/s and disability scores, including ODI and RMQ scores. This suggested that decreased strength in the trunk extensor muscle reflected increased disability in DSD patients, consistent with previous reports. Keller *et al.* [35] observed that the correlation coefficient between trunk extensor PT at 60°/s and ODI was -0.57 in LBP patients. Kudo *et al.* [36] suggested that when compared with the sagittal position of spinal and lower limbs, trunk extensor strength was the most reliable index of RDQ scores in the elderly. Seo *et al.* [34] showed that is negatively correlated with ODI score. A significant relationship was observed between trunk flexor PT at 120°/s and ODI scores in our study. Vieira *et al.* [37] showed that the strength of abdominal muscles in elderly patients with lumbar osteoarthritis, was directly proportional to their quality of life. Based on current data, we propose that both extensor and flexor muscles of the trunk are important for quality of life, while extensor muscle strength may be more important.

We also found that both trunk extensor and flexor strength predicted physical functioning and role-physical scores. Previous studies have shown that weakness in trunk muscle strength in the elderly, leads to increased fall tendencies, impaired mobility, impaired daily living activities and increased disability [38]. While strong trunk muscles can not only decrease the kyphotic, but also accelerate the recovery of normal physical activities [39]. Thus, trunk muscle strengthening should be considered a specific intervention in preventing spinal deformity.

Our data showed that isokinetic trunk extensor strength at 60°/s and trunk flexor strength at 120°/s predicted patient HQOL. This discrepancy in velocity may be related to variant muscle fiber recruitment, and pathological deterioration in strength at different speeds [15]. We propose that muscle contraction intensity of trunk extensor and flexor muscles coincide with the set compliant resistance of IKD at 60°/s and 120°/s, respectively. Therefore, it better reflects the true level of muscle and its impact on patient quality of life. As we did not evaluate patient muscle contraction intensity using electromyography, further research is required in this area.

Our study had some limitations. Firstly, participants were recruited from a single center, and the sample size was relatively small. However, this was the first study to report isokinetic trunk muscle strength in patients with degenerative spinal deformity, and its association with HQOL. Secondly, DSD is often combined with degenerative discs, endplate degeneration and other degeneration, however these factors were not considered here, and thus may affect some quality of life, potentially introducing some bias to our data. Thirdly, there were fewer males, and primarily scoliosis deformities in our sample. Therefore, in future studies, we will expand sample size and make comparisons between patients of different genders and deformities.

## Conclusions

We showed that isolated trunk extensor myopathy in DSD causes an imbalance in trunk muscle strength. In addition, isokinetic trunk extensor strength at 60°/s and trunk flexor strength at 120°/s predicts disability and physical HQOL in these patients. These preliminary data may provide a clinical intervention strategy to improve trunk function, thus improving DSD patient HQOL.

## Abbreviations

DSD

Degenerative spinal deformity; HQOL:Health-related quality of life;BMI:Body mass index;F/E:Flexion/extension;VAS:Visual analogue scale;ODI:Oswestry Disability Index;RDQ

Roland-Morris disability questionnaire;SF-36

36-item Short Form Health Survey

## Declarations

### Acknowledgements

Not applicable.

### Authors' contributions

YS,CC and DSY carried out the studies, participated in collecting data, and drafted the manuscript. TY, LK and YXK performed the statistical analysis and participated in its design. TJL,ZCM RZG and XJZ helped to draft the manuscript. LF and WWJ designed the present study and revised the manuscript .All authors read and approved the final manuscript.

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## Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Ethics approval and consent to participate

Ethical approval for this study was obtained from Ethical Committee of the First Affiliated Hospital, Third Military Medical University, PLA (Protocol number KY201853). Written informed consent was obtained from all participants before the study.

## Consent for publication

Written informed consent was obtained from the patient for publication of this case report and any accompanying images.

## Competing interests

All authors declare that they have no competing interests.

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## Figures

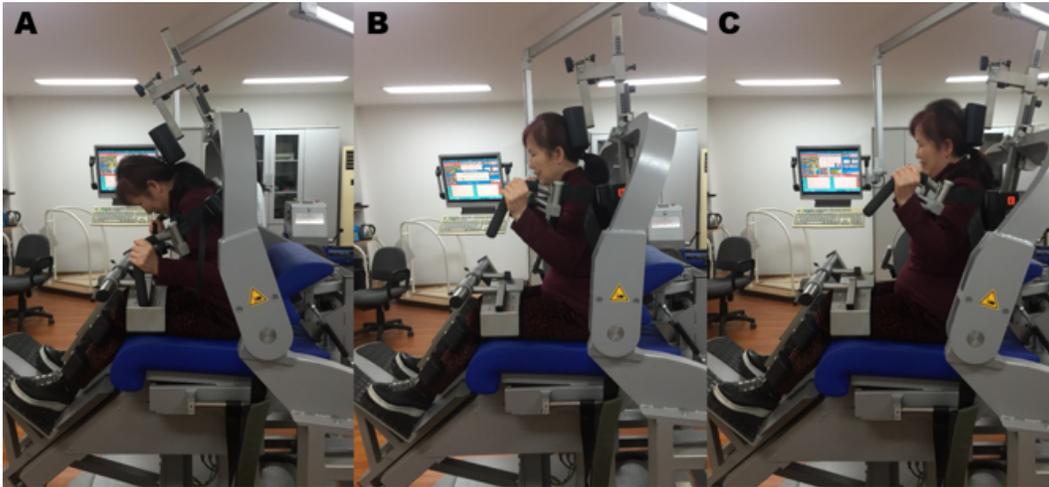


Figure 1

Isokinetic trunk muscle strength test. Illustration: Participant performing a maximum effort of trunk flexion-extension in the isokinetic dynamometer with a range of motion of 40° (A) -20° trunk flexion (B) 0° initial position (C) 20° trunk extension.

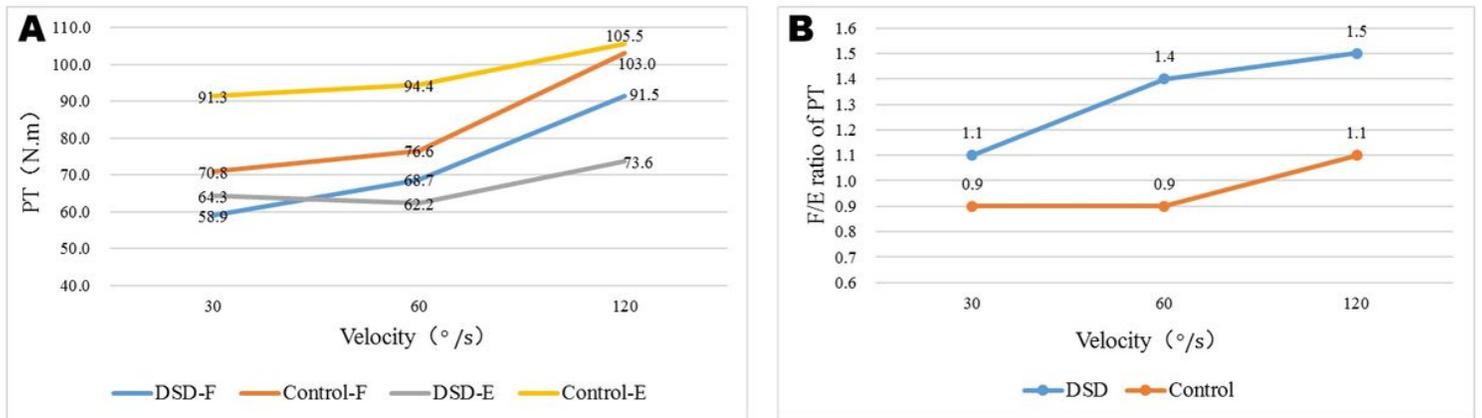


Figure 2

The velocity-changing trend diagram of isokinetic strength of trunk muscle. Illustration: (A) The trunk flexor and extensor PT in the control group were always higher than that in the DSD group, the trends of flexor PT growth of two groups were basically the same and the extensor PT in the control group maintained an increasing trend, while there is a mild downturn for extensor PT from the speed of 30°/s to 60°/s in the DSD group. (B) The F/E ratio in the control group was stable between 0.9 and 1.1, while the F/E ratio maintained an increasing trend from 1.1 to 1.5 in DSD group. PT: peak torque; DSD: degenerative spinal deformity; F: flexion; E, extension

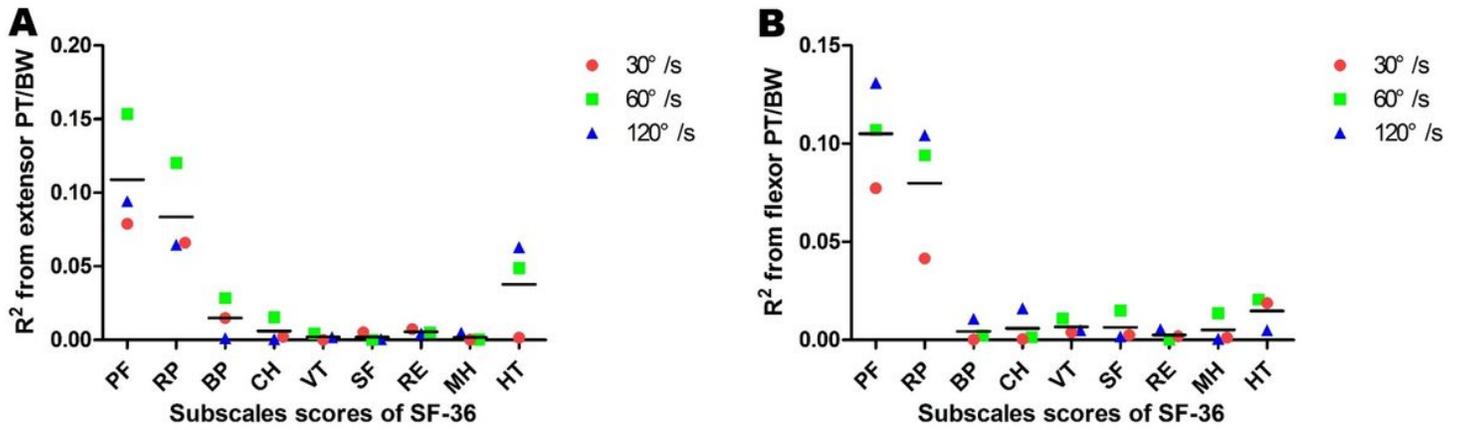


Figure 3

The scatter plot of determination coefficient from PT/BW of trunk muscle on subscales of SF-36. Illustration: (A) The PF and RP were the index most affected by the PT/BW of trunk extensor, especially at the speed of 60°/s. (B) The PF and RP were the indicators of the greatest influence of the PT/BW of trunk flexor, especially at the speed of 120°/s. PT: peak torque; BW: body weight; SF-36: 36-item Short Form Health Survey; PF: physical functioning; RP : role physical; BP, bodily pain; GH, general health; VT, vitality; SF, social functioning; RE, role emotional; MH, mental health; HT, health transition

## Supplementary Files

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