The Roles of Lumbar load thresholds in lifetime cumulative lifting exposure to predict disk protrusion

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Abstract

Background: The purpose of this study was to determine whether if a specific threshold value exists in each lifting load, the accumulation above which best predicts lumbar disk protrusion, or on the other hand, all lifting load should be accumulated. Methods: This was a cross-sectional study. Subjects with various lifetime lifting exposures were recruited. Disk protrusion was determined by magnetic resonance imaging. Lifetime cumulative lifting load was the sum of time-weighed lumbar load for each job using a biomechanical software system. For accumulation above different thresholds, predictive capabilities for disk protrusion were compared using four statistical methods. Results: A total of 252 men and 301 women were included in the final analysis. For men, 3000 Newton for each lifting task was the optimal threshold value for predicting L4-S1 disk protrusion, whereas for women, 2800 Newton was optimal. Our findings suggested that when considering lifetime exposure, including all lifting loads without defining a minimal exposure limit might not be the optimal method for predicting disk protrusion. Conclusions: The NIOSH 3400 Newton recommended limits do not appear to be optimal threshold for preventing disk protrusion. Different lifting thresholds might be applied to men and women in the workplace for safety.

Background

Numerous studies have found relationship between occupation workload and disk protrusion,[1–8] which may lead to sciatica, low back pain (LBP), and even long-term disability. Disk protrusion has been listed as an occupational disease and compensated in many countries, such as Denmark, France, Germany, United States, and Taiwan.[7] Recent decades, researchers have reported that lifetime cumulative lifting load has been related to disk protrusion in a dose-dependent manner.[5–8] However, lifting objects with various weights is inevitable in everyday work and life. A crucial question is whether a specific threshold value exists in each lifting load, the accumulation above which best predicts lumbar disk protrusion, or on the other hand, all lifting load should be accumulated.

A review of the literature revealed several recommended lifting threshold, although most of them were used in the prevention of low back injury.[9–16] For example, the National Institute for Occupational Safety and Health (NIOSH) of the United States suggested that if spinal compression exceeds approximately 3400N(Newton), workers would be at an increased risk of low back injury.[17] Nevertheless, those recommended lifting limits might not be practicable for calculating the cumulative effects for several reasons. First, they were examined for a single spontaneous lifting and the career-long effects of repeated lifting were not considered. Second, most of them were proposed for preventing LBP, not for to disk protrusion. Third, the current 3400N recommended values do not appear to be optimal because more than 50% of work-related low back injuries are attributed to tasks involving the manual handling of materials.[18] Fourth, uniform lifting limits are not generalizable across ethnicity and sex. Accordingly, this study was conducted to determine the optimal lifting threshold per lift for calculating the lifetime cumulative load in order to prevent disk protrusion in Asian, and to determine whether the threshold value differs between men and women.

Methods

Study Population

This was a cross-sectional study. The protocol and consent forms of the study were reviewed and approved by the National Taiwan University Hospital Research Ethics Committee (NTUH-REC No.:200805047R). Recruitment of the participants, measurements of the work exposure, and imaging studies of the lumbar spines were detailed elsewhere.[8] To obtain a broad spectrum of lifting exposures, the participants were recruited from 2 populations: (1) walk-in clinic patients and (2) workers who carry heavy loads. Patients visited the Internal Medicine Clinic of National Taiwan University Hospital and diagnosed with upper respiratory infections (URI), mostly the common cold, were recruited as the background population. The group that carried heavy loads were workers from one fruit and vegetable wholesale market. Lifting is a daily routine task for these workers. During recruitment, the market workers and the walk-in patients were not informed of the hypothesis of the study. They were invited to participate in an investigation regarding spine and bone disorders. The inclusion criteria were between 20 and 65 years and at least 6 months of working experience. Participants diagnosed with several health conditions described previously were excluded.[8] We combined these 2 populations to examine the effects of lifting on disk protrusion. Before participating in the study, all workers and patients received written and oral information regarding the study procedures and potential adverse effects, and signed informed and published consent forms.

Data Collection

Each participant was asked to complete a questionnaire and to obtain magnetic resonance imaging (MRI) of the lumbar spine. A detailed structured interview was implemented to the participants for assessing the relevant work tasks in each job held since they entered the workforce. The occupational history included job titles, tenures, body weights at each job, descriptions of tasks, carry load, lifting frequency and duration, working hours per day and working days per week. The participants were encouraged to recall their body weights during the period of each job. When the job period was longer than 5 years, the average body weight during this job period was used.

Estimation of Lumbar Disk Compression Load

The method of lumbar disk compression load estimation has been published previously.[8] Regarding the estimation of lifetime exposure, the participants recalled all of the jobs held after completing schooling, and the weight, frequency, and duration of each task. The participants performed a typical material handling task to simulate the positions and weights encountered at each job. Lifting activity was divided into a sequence of static postures, including the initial lift-up, transferring, and unloading postures, and each posture was analyzed. The initial position of the weight lifting task was defined as the lift-up posture, the final position was defined as the unloading posture, and the action of transferring material while walking was defined as the transferring posture. Although the initial and final positions of lifting may have varied during a typical day of materials handling on the job, the selected typical tasks, including the simulated positions and weights, were used to calculate the compression load to represent the job. The compression load on the disk during lifting was estimated using the 3D Static Strength Prediction Program (3DSSPP, University of Michigan, Michigan) software system.[19 20] Anthropometric data such as sex, height, body weight, carried weight, and working posture photograph of each participant were input into the system to predict lumbar load. To evaluate the intrarater and interrater reliability of lumbar load estimation by 3DSSPP, photographs of the simulated work conditions of the 60 study participants were repeatedly evaluated in 2 rounds, with the second round of evaluation was conducted 4 weeks after the first round.

Calculation of Lifetime Cumulative Lifting Load on the Lumbar Disk

To investigate the actual cumulative lifting exposure, the participants recalled details regarding lift-up time ($t_{lift\text{-}up}$), transporting time ($t_{transporting}$), and unloading time (t_{unload}) of each lifting task at their jobs. Hence, in this study, the lifting exposure of each task was defined as the sum of the products of the lift-up force ($F_{lift\text{-}up}$) and lift-up time, transporting force ($F_{transporting}$) and transporting time, and unloading force (F_{unload}) and unloading time. Only those lift-up forces greater than proposed threshold value were added into lifetime exposure. For each job described, the lifting exposure was calculated as the product of the lifting load and the duration of lifting in hours (Newton × hour, Nh). The lifetime cumulative load for each participant was then calculated by summing the lifting exposure on the lumbar disk from all jobs.

The threshold value in this study was defined as exposure with a lifting load above this proposed value was considered as contributed to disk protrusion over an entire career life, and was included in the lifetime cumulative calculation. The proposed threshold values were set at zero Newton (N), and at 100N increments from 2000 to 4000N. For example, if the threshold value is set as 3400N, only lifting load above 3400 N per lift will be included in the calculation. And, when the threshold value is set at 0 N, every lifting load generated from each activity will be included in the calculation. The calculation was expressed as the following equation:

Cumulative lifting load =

$$\sum [(F_{lift\text{-}up}*t_{lift\text{-}up} + F_{transporting}*t_{transporting} + F_{unload}*t_{unload})/3600 * \text{frequency of lifting/day} * \text{working days/year} * \text{working year}]$$

where F represents the lifting load on the lumbar disk and t represents time (seconds).

The reproducibility of the lifting measurements was tested 6 months after the initial interview with the help of 25 participants. Their current jobs were used for reliability testing. These measurements included the working tenure, lifting weights, frequency of lifting per day, and lift-up time of the job. After observing and recording the fruit workers' practices, we found that most of the participants' lift-up time was almost equal to their unloading time and that the transporting time was zero. Therefore, the reliability of the transporting time and unloading time was not examined. In addition, we determined that pushing or pulling is not a common task for the majority of fruit market workers because they typically drive an electric pedicab to transfer fruit boxes. Therefore, the lumbar load of pushing and pulling was not assessed.

Each intervertebral disk at L4–L5 to L5–S1 was evaluated for disk bulging, protrusion, extrusion, and sequestration using MRI. All MRI examinations were conducted at the National Taiwan University Hospital. MRI equipment and protocol, definition of disk condition above, the evaluation of intrarater reliability regarding the presence or absence of protrusion were described previously.[8]

Data Analysis

The reproducibility of the calculation of the lifting load and lifting measurements was analyzed using SPSS version 16.0 for Windows (SPSS Inc, Chicago, Illinois) to compute intraclass correlation coefficients (ICCs). Kappa was used to assess the intrarater reliability of disk protrusion. Logistic regression analysis using JMP 5.0 (SAS Institute Inc, Cary, North Carolina) was applied to identify the association between lifetime cumulative lifting load and disk protrusion at either of the lower disk levels, namely, L4-L5 and L5-S1 disk, adjusting for potential risk factors including age, body mass index (BMI), and smoking. $P < 0.05$ was considered to be statistically significant. To determine the best threshold of lifting load, four statistical values were used to compare outcome (L4-S1disk protrusion) to lifetime cumulative load while different threshold values was applied, namely, (1) Area under the curve (AUC) of a receiver operating characteristic (ROC) curve, (2) Coefficient of determination (R^2, (3) Akaike information criterion (AIC), and (4) Bayesian information criterion (BIC). We compared the AUC in various models that were plotted using MedCalc for Windows Version 9.2.1.0 (MedCalc Software, Mariakerke, Belgium). Models with higher AUC statistics were considered as the optimal model. The amount of cumulative lifting load explained by various threshold values in the model was evaluated based on the R^2 statistic. AIC and BIC were obtained using SAS Version 9.1 (SAS Institute Inc.) AIC is closely related to BIC. Given a set of candidate models for the data, the preferred model is the one with the minimal AIC value, and the same applies to BIC.

Results

A total of 553 volunteers were included in the final analysis; 252 participants were men (mean age 49.8 years, standard deviation (SD): 11.7) and 301 were women (mean age 51.3 years, SD: 9.4). The demographic characteristics of the participants are shown in Table 1. The men exhibited higher BMI values (25.6 + 3.1 kg/ m^2) than women did (24.1 + 3.8 kg/ m^2), and most participants had more than 15 years of work experience (75.6%). LBP during the past 6 months was reported by approximately 83.6% of the participants. The reproducibilities of lifting measurements were high for working tenure (ICC = 0.943), lifting weights (ICC = 0.945), and frequency of lifting per day (ICC = 0.914), and moderate for lift-up time (ICC = 0.743). The intrarater and interrater reliabilities of lifting load calculation were 0.998 and 0.992 (ICC), respectively. The Kappa value of intrarater reliabilities for L4-S1disk protrusion was good with 0.850.

Figure 1 and Figure 2 showed the predictive abilities of lifetime liftload with different threshold to L4-S1 disk protrusion in male and female participants, respectively.

The detail information were shown in Supplemental Table 1 and Supplemental Table 2. With any of the threshold values, the lifetime cumulative lifting load was significantly associated with L4-S1 disk protrusion. Among the male participants, the maximal AUC (0.686) was found while lifting load of 3000N was used as threshold (Figure 1(a) and Supplemental Table 1). The R^2 statistic (0.0797), AIC (−390.3), and BIC (−387.8) were also optimal when 3000N (Figure 1(b), (c), (d) and Supplemental Table 1). The ROC curves of 3400N, 3000N, and 0N models in male were showed in Figure 3. Among the female participants, the maximal AUC (0.615) was found while lifting load of both 2800N and 3000N were used as threshold (Figure 2(a) and Supplemental Table 2). The R^2 statistic (0.0321), AIC (−501.1), and BIC (−498.6) were also optimal when 2800N (Figure 2(b), (c), (d) and Supplemental Table 2). The ROC curves of 3400N, 2800N, and 0N models in female were showed in Figure 4.

Table 2 and 3 showed adjusted odds ratios (aORs) for disk protrusion when lifetime cumulative load was calculated by various thresholds as predictors. In male, the cumulative load with 3000N and 0N thresholds were categorized into low, intermediate, and high tertiles. For the 4000N and 3400N thresholds, the grouping were low (0 Nh), and dichotomies (intermediate and high) among those with cumulative loads above 0 Nh. The cumulative load of above 3000N provided most significant association with L4-S1 disk protrusion (aOR = 3.1, 95% Confidence Interval (CI) 1.5–6.7; aOR = 2.9, 95% CI 1.4– 6.2) as compared to those using 0 N, 3400N, and 4000N (Table 2). In female, the cumulative load with 0N threshold was categorized into low, intermediate, and high tertiles. For the 4000N, 3400N and 2800N thresholds, the grouping were low (0 Nh), and dichotomies (intermediate and high) among those with cumulative load above 0 Nh. The cumulative load of above 2800N provided most significant association with L4-S1 disk protrusion (aOR = 2.6, 95% CI 1.0–6.2; aOR = 2.7, 95% CI 1.4–5.4; aOR = 2.3, 95% CI 1.1–4.8) as compared to those using 0 N, 3400N, and 4000N (Table 3).

Discussion

This study found optimal threshold values of load per lift which allow for best prediction of disk protrusion by cumulating exposures. Cumulative lifting load provided best prediction for L4-S1 disk protrusion when the threshold value was set at 3000N for male, and 2800N for female participants.

One of the recommended lifting limits, the NIOSH 3400N, is widely used by ergonomists as well as health and safety practitioners.[12 21] It is based on the studies by Evans and Lisner [22], and Sonoda[23]. These studies show that microfractures of the vertebral cartilage endplates started to happen among cadavers of subjects 60 or more years old, when applying average axial loads of 3400N. The major limitations of NIOSH 3400N are that the results are based on cadaver studies and immediate effects on the vertebral cartilage end plate, but not for cumulative effects. Our study is important complement to the NIOSH 3400N criteria and provides recommendations to long-term lifting limits.

To our best knowledge, only few studies examined dose-effect relationship between lifetime cumulative lifting load and disk protrusion. Seilder [5] conducted a thorough investigation of all past lifting load for the participants. They showed that male workers who had been exposed to 5 - 21.5 × 10^6 Nh lifetime lifting load exhibited a 1.7-fold risk of disk protrusion comparing to those exposed to 0—<5 × 10^6 Nh, suggesting cumulative effects of all lifting loads, without threshold, on disk protrusion.[5–7] In a later study,[8] participants who had been exposed to high lifting load (≥8.9 × 10^6 Nh) exhibited an OR of 2.2 for disk protrusion, as compared to those exposed to a low lifting load (<4.9 × 10^5 Nh). This latter study also assumed no per lift threshold for cumulated load. In this current study, a concept of threshold per lift load was tested, and the result showed that applying certain thresholds provided better prediction in calculating lifetime cumulative load than not. Our findings suggested that when calculating lifetime exposure, including all lifting loads without defining a minimal exposure limit might not be the optimal method for predicting disk protrusion.

Considering disk protrusion as the health outcome, male participants seemed to tolerate higher lumbar load than females in a per lift load basis. It is possible that men generally had larger cross-sectional areas in lower lumbar disks than women[24]. The larger areas allowed men to endure higher compression load. Thus, the results of this investigation suggest that different lifting thresholds should be applied to men and women in the workplace for safety.

The strengths of our study were the detail investigation of the lifetime lifting exposure, outcome assessment by using MRI, and applying the concept of threshold per lift to lifetime cumulative lifting load calculation. However, there were several limitations in this study. First, the AUC, R^2, AIC, and BIC statistics are the summary scores of prediction using each threshold value. They did not allow for statistical comparisons among the proposed threshold values. Second, we relied on the participants' memories regarding their occupational history and relevant work tasks from several decades ago. Although the repeatability of current job tasks was examined and found to be satisfactory, the reliability of the information pertaining to previous jobs was difficult to determine. In order to enhance reliability, a structured interview was executed to provide the participants with adequate time for recalling the work details of their previous jobs. The trained interviewers used life milestones to help the participants recollect the necessary details, and captured the working simulation photos by following a standard procedure. Studies have indicated that self-reported data did not provide satisfactory validity.[25] However, Pope showed the accuracy of self-reported manual material handling activities and presented satisfactorily accurate results regarding frequency, duration, and amplitude.[26] Direct measurements obtained using work or laboratory simulations yield the most accurate information; however, it is impractical by using such methods in retrospective studies involving relatively large sample sizes.

Conclusions

In this study, we applied the concept of threshold value per lift into lifetime cumulative lifting load calculation. Our findings suggested that considering all lifting loads into lifetime exposure calculation without defining a minimal exposure limit might not be practical approach for predicting disk protrusion. In addition, the NIOSH 3400N may not be optimal threshold for preventing disk protrusion. Different lifting thresholds might be applied to men and women in the workplace to prevent injury.

Abbreviations

NIOSH: National Institute for Occupational Safety and Health

N: Newton *URI:* upper respiratory infections *MRI:* magnetic resonance imaging

NTUH-REC: National Taiwan University Hospital Research Ethics Committee

3DSSPP: 3D Static Strength Prediction Program

Nh: Newton × hour, *L4:* the fourth lumbar spine vertebra

L5: the fifth lumbar spine vertebra S1: the first sacrum spine vertebra

ICCs: intraclass correlation coefficients *BMI:* body mass index

AUC: Area under the curve *ROC:* receiver operating characteristic

AIC: Akaike information criterion *BIC:* Bayesian information criterion

MedCalc: MedCalc Software, Mariakerke, Belgium

JMP: statistic software, SAS Institute Inc, Cary, North Carolina

SPSS statistic software, SPSS Inc, Chicago, Illinois

$R^{2:}$ Coefficient of determination *SD:* standard deviation

$kg/\ m^{2:}$ kilogram per square meter *P:* p value

aORs: adjusted odds ratios *CI:* confidence interval

Declarations

Ethics approval and consent to participate

The protocol and consent forms of the study were reviewed and approved by the National Taiwan University Hospital Research Ethics Committee (NTUH-REC No.:200805047R). Before participating in the study, all workers and patients received written and oral information regarding the study procedures and potential adverse effects, and signed informed and published consent forms.

Consent for Publication

All subjects signed consent forms for publication before participating in the study.

Availability of data and material

The dataset used for analysis during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

YLG, SHL, TTFS, and IYJH provided concept/idea/research design. YLG and IYJH provided drafting or critically revising the article. YLG, BBC and IYJH provided data collection and analysis. YLG, TTFS and IYJH provided project management. YLG provided fund procurement. TTFS and YLG provided facilities/equipment and consultation. IKH provided institutional liaisons. All authors read and approved the final manuscript and revisions.

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Tables

Table 1. Demographic characteristics of the study participants

Variables	Male, N= 252 N (%)	Female, N= 301 N (%)	All, N= 553 N (%)
Age, mean $\pm$ SD (years)	49.8 $\pm$ 11.7	51.3 $\pm$ 9.4	50.6 $\pm$ 10.5
< 40	55 (21.8)	37 (12.3)	92 (16.6)
40~<50	51 (20.2)	71 (23.6)	122 (22.1)
50~<60	95 (37.7)	142 (47.2)	237 (42.9)
$\geq$ 60	51 (20.2)	51 (16.9)	102 (18.4)
BMI, mean $\pm$ SD (kg/m^2)	25.6 $\pm$ 3.1	24.1 $\pm$ 3.8	24.8 $\pm$ 3.5
< 24	73 (29.0)	151 (50.2)	224 (40.5)
24~<27	103 (40.8)	93 (30.9)	196 (35.4)
$\geq$ 27	76 (30.2)	57 (18.9)	133 (24.1)
Lifetime work tenure (years)			
< 15	59 (23.4)	76 (25.3)	135 (24.5)
15~<30	82 (32.5)	127 (42.3)	209 (37.9)
$\geq$ 30	111 (44.0)	97 (32.3)	208 (37.7)
Education Level			
Junior high and below	78 (31.5)	117 (39.4)	195 (35.8)
Senior high school	121 (48.8)	133 (44.8)	254 (46.6)
College or above	49 (19.8)	47 (15.8)	96 (17.6)
Low back pain (within 6 months)	211 (84.1)	246 (83.1)	457 (83.6)
Cigarette smoking (pack-years)			
0	138 (55.0)	288 (95.7)	426 (77.7)
1~<20	43 (17.1)	13 (4.3)	52 (9.5)
$\geq$ 20	70 (27.9)	0 (0.1)	70 (12.8)
Exercise* (Yes)	171 (67.9)	185 (62.5)	356 (65.0)

BMI, body mass index; SD, standard deviation

*Yes means ever having regular exercise for 30 minutes or longer each session, at least one session per week, minimum duration of 3 months, from age of 12 years to the present time.

Table 2. The association between L4-S1 disk protrusion and lifetime cumulative lifting load in male participants

Lifetime cumulative lifting load (Newton-hr)			n	Disk protrusion at lower disk level (L4-S1) AOR
Only lift load above 4000 N was included	Low	0	137	1
	Intermediate	$0\sim< 4.0\times10^{6}$	58	1.6 (0.8-3.1)
	High	$\geq 4\times10^{6}$	57	1.9 (1.0-3.8)
Only lift load above 3400 N was included	Low	0	96	1
	Intermediate	$0\sim< 4.0\times10^{6}$	73	1.6 (0.8-3.3)
	High	$\geq 4\times10^{6}$	83	2.0* (1.0-3.9)
Only lift load above 3000 N was included	Low	$< 2.5\times10^{5}$	84	1
	Intermediate	$2.5\times10^{5}\sim< 5.6\times10^{6}$	83	2.9*** (1.4-6.2)
	High	$\geq 5.6\times10^{6}$	85	3.1** (1.5-6.7)
lift load above 0 N was included	Low	$< 1.8\times10^{6}$	83	1
	Intermediate	$1.8\times10^{6}\sim< 1.6\times10^{7}$	84	2.3* (1.2-4.9)
	High	$\geq 1.6\times10^{7}$	85	2.0 (1.0-4.2)

Adjusted for age, BMI, smoking

Statistically significant: *, P<.05; **, P<.01; ***, P<.001.

Table 3. The association between L4-S1 disk protrusion and lifetime cumulative lifting load in female participants

Lifetime cumulative lifting load (Newton-hr)			n	Disk protrusion at lower disk level (L45-S1) AOR
Only lift load above 4000 N was included	Low	0	254	1
	Intermediate	$0\sim< 2.0\times10^{6}$	24	0.7 (0.2-1.9)
	High	$\geq 2.0\times10^{6}$	23	2.6* (1.0-6.2)
Only lift load above 3400 N was included	Low	0	206	1
	Intermediate	$0\sim< 2.5\times10^{6}$	47	1.6 (0.7-3.4)
	High	$\geq 2.5\times10^{6}$	48	1.9 (0.9-3.9)
Only lift load above 2800 N was included	Low	0	142	1
	Intermediate	$0\sim< 1.8\times10^{6}$	79	1.9 (0.9-3.7)
	High	$\geq 1.8\times10^{6}$	80	2.7** (1.4-5.4)
lift load above 0 N was included	Low	$< 1.26\times10^{5}$	99	1
	Intermediate	$1.26\times10^{5}\sim< 5.6\times10^{6}$	101	2.0 (1.0-4.1)
	High	$\geq 5.6\times10^{6}$	101	2.3* (1.1-4.8)

Adjusted for age, BMI, smoking

Statistically significant: *, P<.05; **, P<.01; ***, P<.001.

Figures

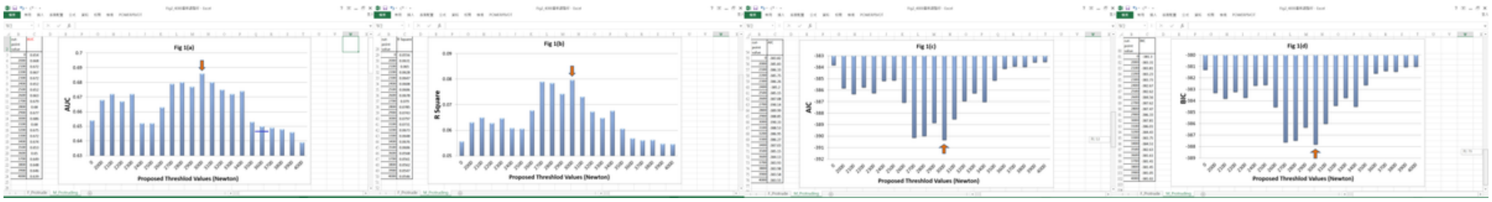

Figure 1

(a). The AUC statistic distrubution of L4-S1 disc protrusion with proposed threshold values in male participants (b). The R Square values of L4-S1 disc protrusion with proposed threshold values in male participants (c). The AIC values of L4-S1 disc protrusion with proposed threshold values in male participants (d). The BIC values of L4-S1 disc protrusion with proposed threshold values in male participants

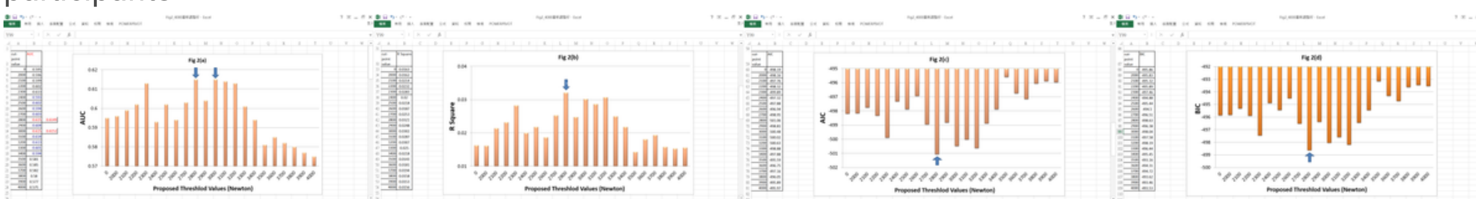

Figure 2

(a). The AUC statistic distrubution of L4-S1 disc protrusion with proposed threshold values in female participants (b). The R Square values of L4-S1 disc protrusion with proposed threshold values in female participants (c). The AIC values of L4-S1 disc protrusion with proposed threshold values in female participants (d). The BIC values of L4-S1 disc protrusion with proposed threshold values in female participants

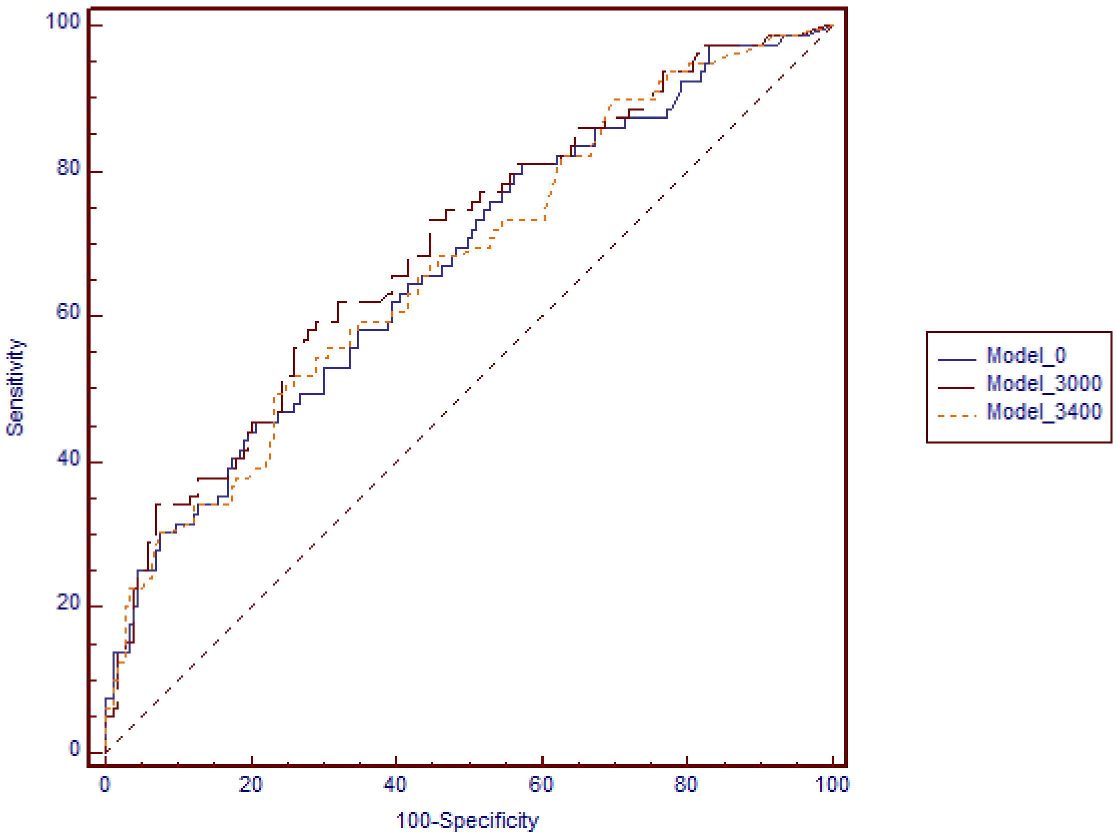

Figure 3

Receiver-operating characteristic curves for the prediction of L4-S1 disc protrusion in male participants by models of different threshold of lifting load. Model 0: AUC (95% CI) = 0.65 (0.61 - 0.71). P = 0.0001 Model 3000: AUC (95% CI) = 0.69 (0.63 - 0.74). P = 0.0001 Model 3400: AUC (95% CI) = 0.67 (0.61 - 0.73). P = 0.0001

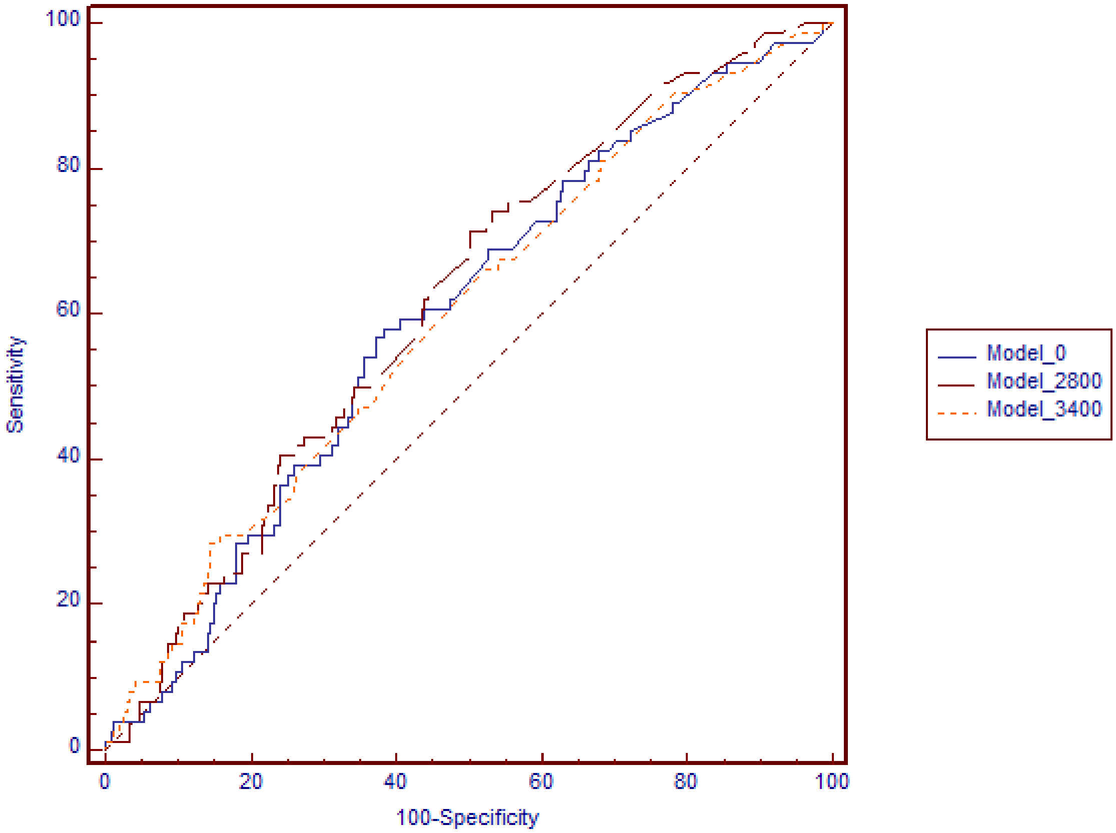

Figure 4

Receiver-operating characteristic curves for the prediction of L4-S1disc protrusion in female participants by models of different threshold of lifting load. Model 0: AUC (95% CI) = 0.60 (0.54 - 0.65). P = 0.0154 Model 2800: AUC (95% CI) = 0.62 (0.56 - 0.67). P = 0.0031 Model 3400: AUC (95% CI) = 0.59 (0.54 - 0.65). P = 0.0159

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- supplement1.doc
- supplement2.docx
- supplement3.pdf