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Changes in spine loading patterns throughout the workday as a function of experience, lift frequency, and personality

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Abstract

BACKGROUND CONTEXT: Psychosocial stressors have been associated with low back pain reporting. However, response to psychosocial risk factors may be dependent on the individual's personality type that, in turn, can affect muscle recruitment and spine loading. This study explores how personality might be associated with spine loading during repetitive lifting performed throughout an entire work shift.

PURPOSE: Assess spine loading as a function of an individual's personality type during repetitive, long-term exposure to a materials handling tasks.

STUDY DESIGN: Laboratory experiment where experienced and inexperienced participants performed repetitive, asymmetric lifts at various load and lift frequency levels throughout a series of 8-hour exposure periods. Spine loads were monitored throughout the work period.

PATIENT SAMPLE: Twelve novice and 12 experienced materials handlers who were asymptomatic for back pain.

OUTCOME MEASURES: Spine compression, anterior-posterior (A/P) shear, and lateral shear at the L5–S1 level.

METHODS: Participants were categorized into personality types based upon the Myers-Briggs personality type indicator. An electromyography-assisted biomechanical model was used to assess spine compression, A/P shear, and lateral shear throughout the exposure period.

RESULTS: The results indicate that intuitors had higher shear spinal loading regardless of moment exposure, lift frequency, and time through the work period, compared with the sensor personality type. In addition, higher spine compressive and shear forces occurred in the perceiver personality compared with the judgers' personality trait, regardless of moment and, often, lift frequency. Novice lifters typically experienced greater spine loading.

CONCLUSIONS: The results suggest that when there exists a personality–job environment mismatch, spinal loading increases via an increase in antagonistic co-contraction. The trends suggest that inherent personality characteristics may play a role in one's motor control strategies when performing a repetitive lifting task.

Keywords: Personality; Low back pain; Spine loads; Electromyography; Spine modeling

Introduction

Work characterized by low job satisfaction, monotonous work, high perceived workload, and time pressure represent psychosocial stressors that have been linked to reporting of low back pain (LBP) [1–4]. While the presence of these stressors may be characteristic of the work environment, the biomechanical response of the individual worker to these stressors may be dependent upon the worker's perceptions about stress. Thus, the complexity of LBP may be represented, in part, by the interactive effect of psychosocial, individual, and biomechanical factors.

The prediction of individual responses to stressors is a difficult task. However, knowledge of worker personality may provide a means to better understand these responses.

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One potential to factor that may play a role in explaining individual responses is personality. Personalities, as defined by Myers and Myers [5], are characterized by different preferences. These preferences are categorized by four contrasting scales consisting of Introvert/Extrovert (IE), Feeler/Thinker (FT), Sensor/Intuitor (SN), and Perceiver/Judger (PJ). According to the Myers-Briggs Type Indicator (MBTI), people's preferences lie along a continuum on each scale, and that may be used to understand their reactions to events. For example, extroverts like variety and action and enjoy people but are impatient with slow jobs, whereas introverts like quiet periods of uninterrupted work and are often poor communicators. Sensors enjoy order at work and are good at precision work, whereas intuitors dislike repetition and prefer to work in spurts. Feelers are people oriented and aware of others' feelings, whereas thinkers are more impersonal and prefer logical order. Judgers dislike interruptions, whereas perceivers adapt well to change.

Allread suggested that there may exist links between personality traits and LBP that are dependent upon the match between the individual's preferences (associated with personality traits) and the job's characteristics [6]. Furthermore, a recent study found that personality traits are associated with muscle recruitment patterns that, in turn, may be responsible for spine loading differences when exposed to psychosocial stress [7].

During exposure to lifting conditions, it is hypothesized that personality-based preferences, when matched to job characteristics, allow the worker to biomechanically respond with more efficient (and less severe) levels of spinal loading. In contrast, when there exists a personality–job mismatch, the level of perceived stress increases which, in turn, increases the trunk muscle activities and can increase the loading on the lumbar spine. Hence, the current study's objective was to investigate whether there existed a difference in the biomechanical responses, in particular, incurred spinal loading, when workers with different personalities were presented with the same work demands within the same environment. Secondarily, this study examined the effect of personality on the incurred spinal loading in both novice and experienced manual material handlers.

Methods

Approach

The purpose of this study was to assess how worker personality traits (as defined by the MBTI) might influence the development of spine three-dimensional loads when workers were exposed to tasks where load weight lifted, lift frequency, and duration of lifting exposure were assessed over an 8-hour period of exposure. This study required both experienced and inexperienced subjects to lift under one of three weight conditions (moment exposure) over six different days where a different lift frequency was assigned on each day. Subjects were asked to lift for an entire 8-hour period. Discomfort ratings were collected hourly over the exposure period. Spine loading was also assessed during the exposure period and was reported in detail in a separate publication.

Subjects

Twenty-four participants (3 females and 21 males) with no prior history of LBP volunteered for this study and received an hourly wage plus a bonus for finishing all test conditions. Twelve novice (no manual material handling [MMH] experience) and 12 experienced (at least 1 year of MMH experience) manual material handlers served as subjects. Subjects' ages ranged from 19 to 33 years. The average (SD) stature and weight for novices was 177 cm (8 cm) and 75 kg (15 kg), respectively and for experienced subjects was 177 cm (4 cm) and 81 kg (16 kg), respectively.

Personality assessments

Subjects completed the Myers-Briggs [5] survey during the study. Participants' personality types were categorized into four categories: Introvert/Extrovert (IE), Feeler/Thinker (FT), Sensor/Intuitor (SN), and Perceiver/Judger (PJ). Each of these personality traits is associated with certain preferences that may influence a subject's responses to a given work situation or task [5,8,9]. For each personality trait, there are certain circumstances that can energize or stress an individual [8]. Personality was typed using a combination of these four primary traits. Reliability of the MBTI has been reported by Bayne [10] and Harvey [11]. Two of these categories (IE and FT) were highly imbalanced with respect to experience level, test conditions, or both, which would yield insufficient statistical power. Thus, these categories are not included. Because the categories are independent of each other [5], the elimination of these categories should not negatively influence the findings. On the other hand, the SN and PJ categories were well balanced and afforded adequate power for the analyses.

Experimental design

The experimental design consisted of a repeated measures design with one between-subjects factor (load moment) and one within-subjects factor (lift frequency). The independent variables included experience level, load moment, lift frequency, and time block. The load moment had three levels: 8, 36, and 85 Nm. The lift frequency had six levels: 2, 4, 6, 8, 10, 12 lifts/min (lpm). Subjects were tested on six separate 8-hour sessions, once under each frequency condition. The effect of time was studied by dividing the 8-hour work day into four 2-hour blocks of time. Two experience levels, novice (no MMH experience) and experienced (at least 1 year of full-time MMH experience) were chosen so that results could be applicable to a wide range of MMH workers.

The dependent variables consisted of the three-dimensional spinal loading predicted by the electromyography (EMG)-assisted biomechanical model (described below) during the experimental task lifts. Compression, anterior-posterior (A/P) shear, and lateral shear in Newtons were all predicted for each personality type. Spinal loading data were collected every 10 minutes throughout the 8-hour session. To allow for comparisons between subjects, spinal loading was normalized to the subject's weight to account for body size (N/N).

Apparatus and EMG-assisted biomechanical model

EMG data were collected using bipolar surface electrodes spaced approximately 3 cm apart over the ten trunk muscles' sampling locations [12]. The myoelectric data was low-pass filtered at 500 Hz, high-pass filtered at 30 Hz, rectified, integrated via a 20-ms sliding window filter, and normalized relative to the maximum voluntary contraction values.

Trunk kinematics were monitored with a tri-axial goniometer (lumbar motion monitor), designed to measure the instantaneous three-dimensional motion of the lumbar trunk [13]. The device design specifications and accuracy have been reported previously [13]. The goniometric position method described by Fathallah et al. in conjunction with a forceplate (Bertec 4060A; Bertec, Worthington, Ohio) were used to document pelvic tilt and rotation during lifting exertions [14].

The EMG-assisted biomechanical model developed in the Biodynamics Laboratory at the Ohio State University over the past 20 years was used to estimate spinal loads. This model has been validated for robustness in sagittal [15] and lateral bending [16], axial twisting [17], lowering exertions [18], and repeated measures [19]. The model also takes into account gender-based anatomical differences in the muscle size [20,21].

Experimental task

Subjects performed whole body free-dynamic lifts, representative of a common palletizing operation [22] with a vertical origin height of 88 cm, vertical destination height of 121 cm, moment arm distance of 74 cm, and lift asymmetry of 90 degrees. One subject lifted the load from the conveyer origin and placed it on the conveyer destination, where it was delivered to the other subject who performed the same operation with an identical load. The task was repeated at the session's specified frequency for 8 hours with typical industrial break schedules.

Data normalization and analysis

Significant effects were statistically analyzed with a repeated measures analysis of covariance structure. Fixed effects were lift frequency and time block. The random effect was subject. Because both random and fixed effects were present, the mixed procedures analysis in the SAS software was utilized to identify significant effects and significant contrasts for the main and interactive effects on the three-dimensional spinal loading, which were considered significant at an alpha level of 0.05 [23].

Results

The mixed analysis of variance model results indicated that the three dimensions of spine loading experienced throughout the continuous, asymmetric lifts were affected by different factors within each of the personality type analyses. In general, the Sensor and Intuitor personality group significantly influenced shear loading, whereas the Perceiver/Judger personality group significantly affected all three dimensions of spine loading. Tables 1 and 2 summarize the significant influences of the Sensor/Intuitor and Perceiver/Judger personality traits upon spine loading, respectively.

Sensor/Intuitor

Compression

As indicated in Table 1, compression was influenced by only one four-way and one five-way interaction with the Sensor/Intuitor trait. Such complex interactions are extremely difficult to conceptualize and will not be presented here.

Anterior-posterior shear

The main effect of the SN personality trait upon A/P shear was significant ($p=.0206$). Intuitors exhibited 12% higher A/P shears than did sensors. The interaction of

Table 1
Summary of significant influences (p values) of the Sensor/Intuitor personality trait upon spine loading

Effect	Compression	AP shear	Lateral shear
Persn	0.4725	0.0206	0.6020
exp*persn	0.6926	0.0873	0.4284
w*persn	0.0799	0.0303	0.0813
f*persn	0.4304	0.3614	0.0260
f*w*persn	0.3086	0.0070	<0.0001
exp*f*persn	0.7542	—	0.0001
b*persn	0.7046	0.0092	0.6110
w*b*persn	0.4196	0.0085	0.1546
exp*b*persn	0.7718	—	0.0333
f*b*persn	0.6955	0.0477	0.1889
f*w*b*persn	0.1497	0.0144	0.6884
exp*f*b*persn	0.3038	—	0.0906
exp*f*w*persn	0.0467	—	0.0008
exp*w*b*persn	0.1808	—	0.0917
exp*f*w*b*persn	0.0340	—	0.0525

Persn=personality; Exp=experience; W=weight or load moment condition; F=lift frequency; B=time of exposure.

Shaded values are significant effects at alpha=0.05.

— term removed for reduced Mixed model.

Table 2
Summary of significant influences (p values) of the Perceiver/Judger personality trait upon spine loading

Effect	Compression	AP shear	Lateral shear
Persn	<0.0001	0.5817	0.0351
exp*persn	<0.0001	0.0089	0.0106
w*persn	0.0039	0.0043	0.4586
f*persn	0.1691	0.0281	0.0733
f*w*persn	0.0128	0.1972	0.0011
exp*f*persn	0.0214	0.6987	0.0906
b*persn	0.3985	0.4500	0.0003
w*b*persn	—	0.1129	0.6579
exp*b*persn	—	0.1152	0.0598
f*b*persn	—	0.4018	0.1083
f*w*b*persn	—	0.3511	0.0214
exp*f*b*persn	—	0.1508	0.5538
exp*f*w*persn	<0.0001	0.0499	0.0801
exp*w*b*persn	—	0.1124	0.8247
exp*f*w*b*persn	—	0.0368	0.0023

Persn=personality; Exp=experience; W=weight or load moment condition; F=lift frequency; B=time of exposure.
Shaded values are significant effects at alpha=0.05.
— term removed for reduced Mixed model.

moment and SN personality on A/P shear was also significant (p=.0303) (Fig. 1). A U-shaped A/P shear pattern appears for subjects exhibiting the sensor personality trait, whereas little change occurs as a function of moment with the intuitor group. The obvious difference in A/P shear occurs at the 36 Nm level for the sensors, whereas A/P shear is fairly similar for the other moment conditions between groups. The U-shaped pattern exhibited by the sensors was consistent regardless of lift frequency and was responsible for a significant moment × lift frequency interaction (p=.0070) (Fig. 2).

The interactive effect of time into the work period and the SN personality trait on A/P shear was also significant (p=.0092). Intuitors increased their A/P shear significantly after the first 2 hours of lifting exposure and remained relatively constant through the rest of the work period (Fig. 3). Between hours 2–4, intuitors exhibited 15% higher A/P shear loads than sensors (p=.0028). Differences between the two groups for the later work periods ranged between 11% and 13% higher within the intuitor group.

Lateral shear

The interaction of experience level and lift frequency with personality SN on lateral shear was significant at p=.0001. Figure 4 shows that within the experienced subjects, sensors had higher lateral shears than intuitors at lift frequencies above 4 lpm. The majority of the significant differences in A/P loading occurred within the intuitor personality type between experience levels.

The interactive effect of experience and time with personality SN on lateral shear was also significant (p=.0333). Within experience levels, there were no significant differences between sensors and intuitors regardless of the time of the workday. Within the experienced subjects, however, intuitors had significantly higher lateral shear forces during the first 2 hours of the day than any other time period throughout the work period (Fig. 5).

The interactive effect of lift frequency and moment with personality SN on lateral shear was significant at p<.0001. As with the trend exhibited for A/P shear, lateral shears also have a U-shaped pattern associated with moment level regardless of lift frequency. Of particular interest was the 85 Nm condition, where a trend was associated with the lift frequencies and was dependent upon personality type. At this moment level, intuitors generally had exhibited decreased lateral shears as lift frequency increased. Alternatively, sensors generally exhibited increased lateral shears with increasing lift frequency.

Perceiver/Judger

Compression

The main effect of the PJ personality trait on compression was significant (p<.0001). Perceivers had 16% higher compressive loads than judgers.

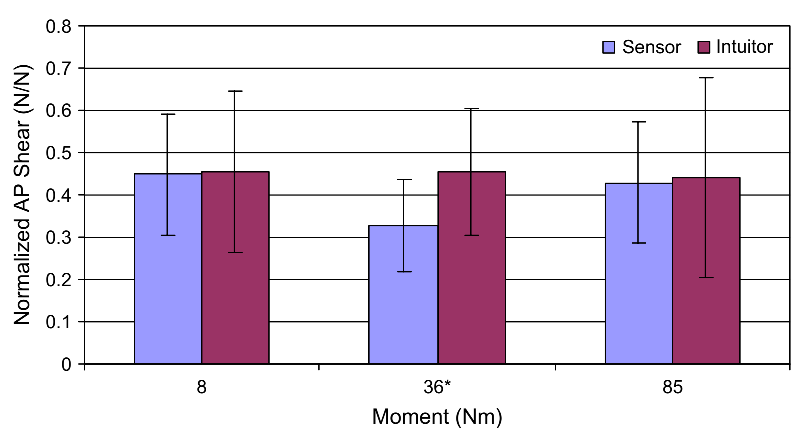

Fig. 1. Interaction of moment and Sensor/Intuitor personality on anterior-posterior shear. Asterisk indicates significant difference between sensors and intuitors. N/N=normalized to body weight.

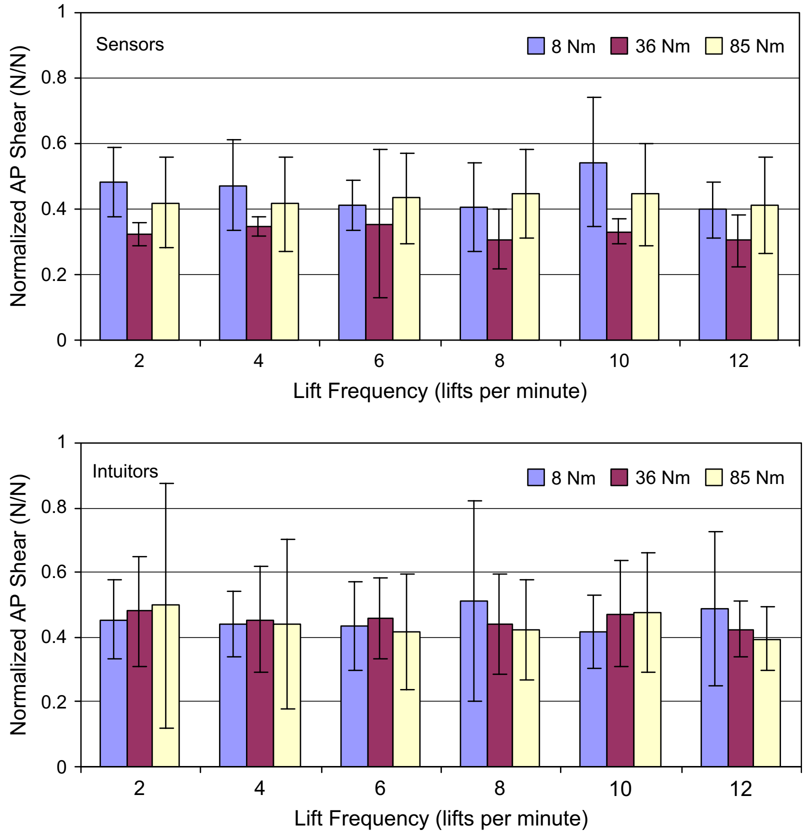

Fig. 2. Interactive effect of frequency and moment on sensors' (top) and intuitors' (bottom) anterior-posterior shears. N/N=normalized to body weight.

The interaction of moment and personality on compression was significant (p=.0039). As shown in Figure 6, perceivers' compression increased with increasing moment, whereas judgers had a significant increase in compressive loads from 8 Nm to 36 Nm, but the load remained constant from lifting at moments of 36 Nm to 85 Nm.

The interaction of experience and personality PJ on compression (p<.0001) indicated that within experienced subjects, perceivers displayed 27% higher compressive loading than did judgers. Experienced perceivers behaved similarly to all novice workers in terms of compressive loading on the spine. The interaction of experience level and frequency with personality PJ was significant at p=.0214. The experienced perceiver subjects exhibited significantly higher compression than judgers for all lift frequencies (Fig. 7). Experienced perceivers generally had 25% higher compressive loads than experienced judgers. There was no significant difference between perceivers and judgers within the novice group regardless of lift frequency.

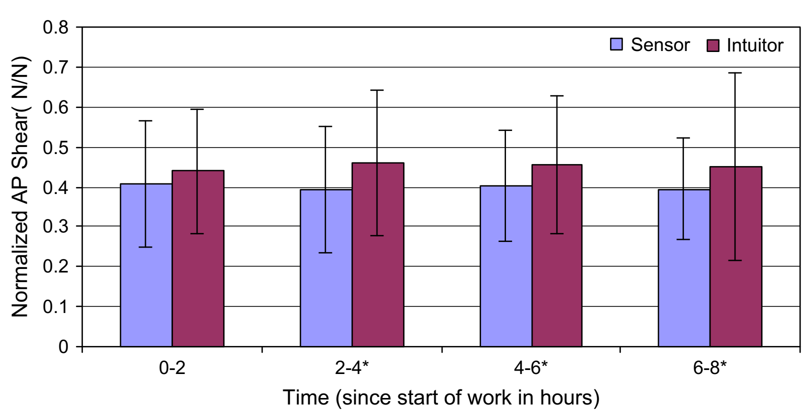

Fig. 3. Interaction of time and Sensor/Intuitor personality on anterior-posterior shear. Asterisk indicates significant difference between sensors and intuitors. N/N=normalized to body weight.

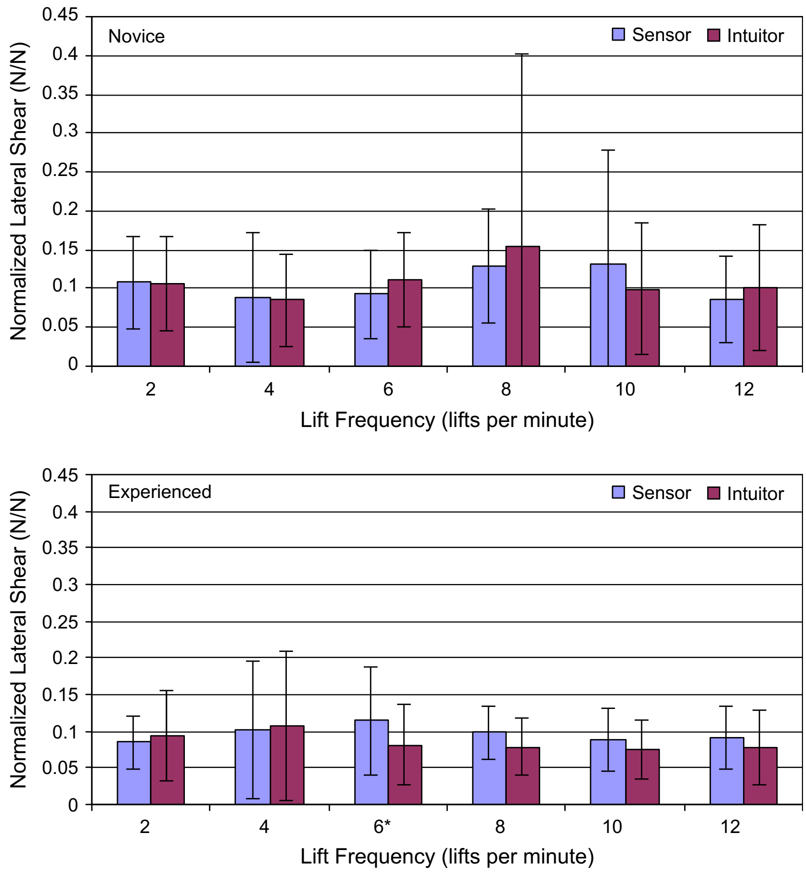

Fig. 4. Interactive effect of frequency and Sensor/Intuitor personality on novice (top) and experienced (bottom) workers' lateral shears. N/N=normalized to body weight.

A/P shear

The interaction of moment and personality yielded a significant A/P shear difference ($p=.0043$) (Fig. 6). Perceivers' A/P shears increased with increasing moment, whereas judgers had decreased A/P shears as the moment increased. At the highest moment level, differences between the personality types are further exacerbated for A/P shear loading on the spine.

The interaction of experience and personality on A/P shear was also significant ($p=.0089$). Novice judgers had 8% higher A/P shears than perceivers, whereas experienced perceivers had 12% higher A/P shear values than judgers.

The interaction of frequency and personality on A/P shear was also significant ($p=.0281$). However, only at 2 lpm did perceivers have significantly higher A/P shears than judgers. Perceivers' A/P shears decreased as lift frequency increased. Lifting at a frequency of 10 lpm elicited the highest A/P shear values for the judgers (Fig. 8).

Lateral shear

The main effect of personality on lateral shear was significant ($p<.0001$). Perceivers produced 12% higher lateral shears than judgers, following the same trend that was exhibited in the compressive spinal loading.

The interaction of experience and personality on lateral shear was also significant ($p=.0106$). As with compression, experienced perceivers had significantly higher lateral shears (29%) than judgers. In contrast, within the novice group, both personality types exhibited similar lateral shear loadings to the experienced perceivers and, as such, both had significantly higher lateral shears than the experienced judgers.

Finally, the interaction of time into the work period and personality PJ on lateral shear was significant ($p=.0003$). Figure 9 indicates that during the last 2 hours of the work period, perceivers had significantly lower lateral shears than at earlier work periods. In general, perceivers had higher lateral shear loading than judgers, and this is consistent with the trend seen in the main effect of personality PJ on lateral shear.

Discussion

This study was the first to investigate the long-term effect of repetitive lifting on the spinal loading of workers with different personality types. The results provide an indication that when there exists a personality–job mismatch, spinal loading may be negatively influenced. Between

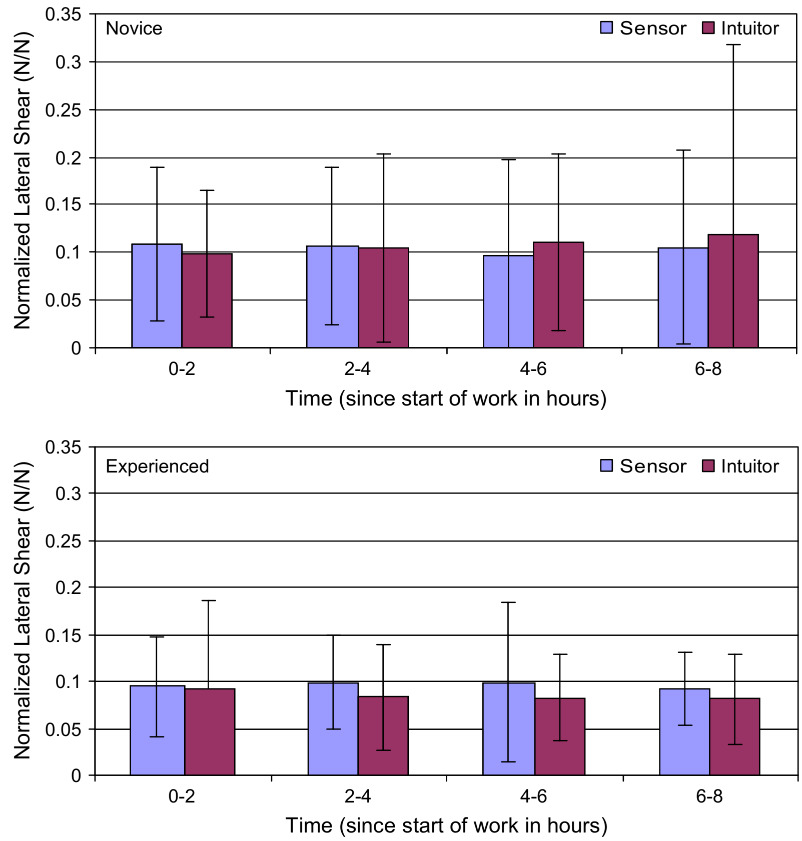

Fig. 5. Interactive effect of time and Sensor/Intuitor personality on novice (top) and experienced (bottom) workers' lateral shears. N/N=normalized to body weight.

sensors and intuitors, intuitors had much higher shear spinal loading. Additionally, between perceivers and judgers, perceivers had higher compressive and shear spinal loading. These trends suggest that inherent personality characteristics may indeed play a role in one's motor control strategies when performing a repetitive lifting task.

Although the literature evaluating personality types and spine biomechanics is limited, a recent study found that personality traits may be responsible for spine loading differences caused by stress [7]. Our results may lend further credence to this concept. Although in the current study no intentional stress was applied, the nature of the task (ie, continuous, repetitive) may have been perceived as stressful by several personality types, namely intuitors and perceivers. This perception of increased stress based on the particular characteristics of the work may be thought of

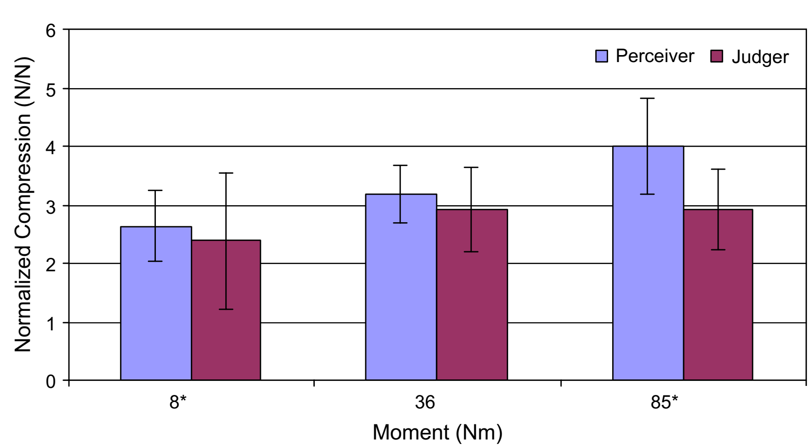

Fig. 6. Interaction of moment and Perceiver/Judger personality on compression. Asterisk indicates significant difference between perceivers and judgers. N/N=normalized to body weight.

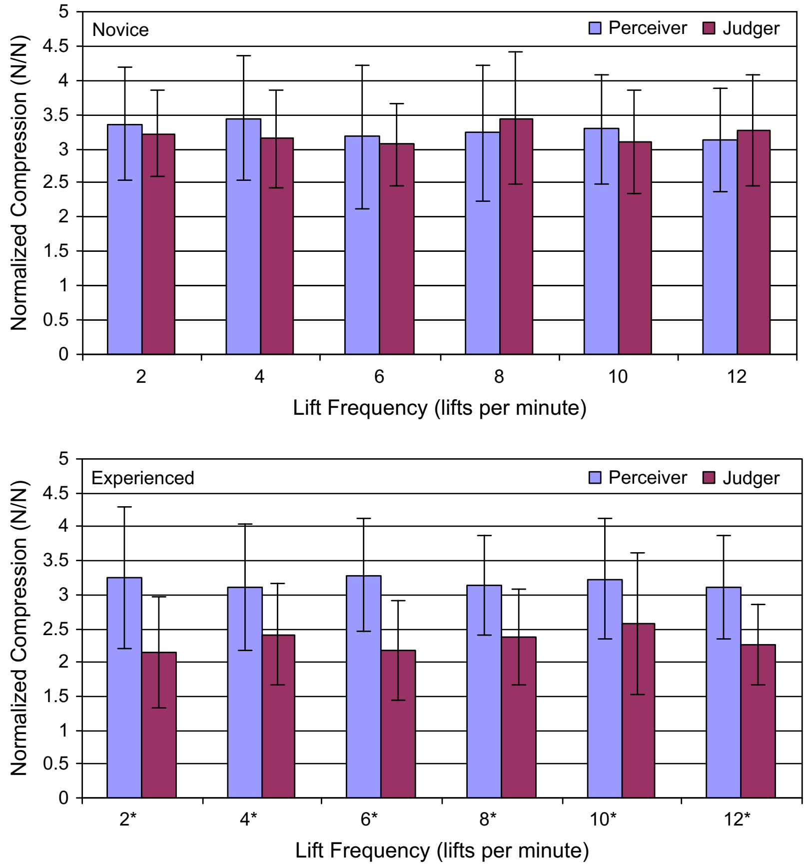

Fig. 7. Interactive effect of frequency and Perceiver/Judger personality on novice (top) and experienced (bottom) workers' compression. Asterisk indicates significant difference between perceivers and judgers. N/N=normalized to body weight.

as a personality–job mismatch. Based on this logic, it is hypothesized that when a personality–job mismatch occurred, the perceived stress manifests itself by increases in muscle coactivity which results in higher spinal loading. In order to support this hypothesis, it is important to consider the characteristics of the personality types studied (Sensors, Intuitors, Perceivers, and Judgers) in relation to the characteristics of the experimental task.

In general, intuitors had higher A/P and lateral shear loading than sensors. A personality characteristic of intuitors is that they dislike doing the same thing repeatedly but prefer rather to learn new skills. The results indicate that intuitors had equally high A/P shear loading regardless of moment, lift frequency, and time. This supports the notion that the task at all experimental levels was mismatched to the intuitors' preferences. Because the experiment

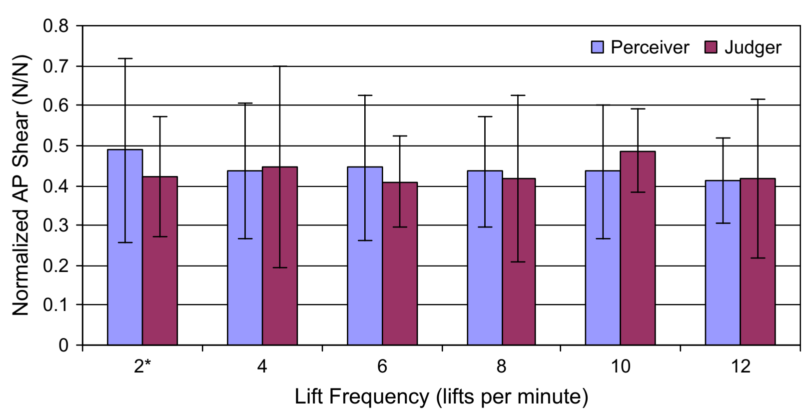

Fig. 8. Interactive effect of frequency and Perceiver/Judger personality on anterior-posterior shear. Asterisk indicates significant difference between perceivers and judgers. N/N=normalized to body weight.

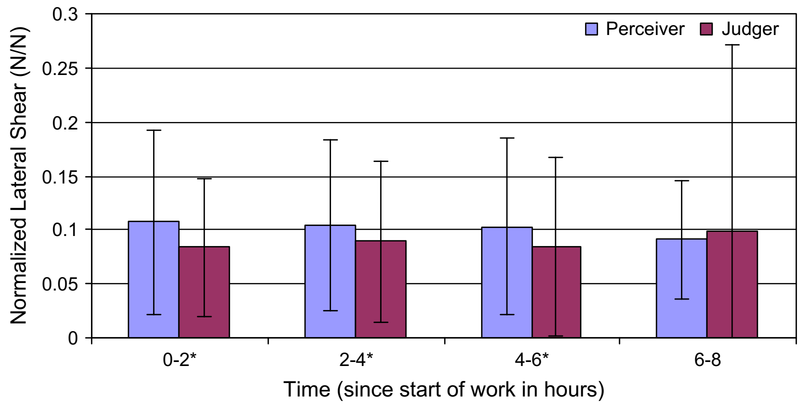

Fig. 9. Interaction of time and Perceiver/Judger personality on lateral shear. N/N=normalized to body weight.

involved repetitively lifting one object of constant mass at the same lift frequency for an 8-hour day, it may be that the personality–job mismatch was the primary influence on how the intuitors selected their motor control strategies for the experimental lift. In other words, because of the mismatch, intuitors may have coactivated their muscles to high levels resulting in high spinal loads for all levels of moment, frequency, and time. The intuitors' adversity to repetitive lifting as reflected in increased spinal loading values has been implied in previous work [7].

Sensors, on the other hand, were more adept at the repetitive task, because they prefer an established work routine [6]. In particular, sensors performed exceptionally well at the 36 Nm level, having, on average, 27% lower A/P shear loading than at the other moment levels and compared with the intuitors. Based on their preferences, this is logical because this moment level is probably representative of the levels at which these subjects typically lifted in their daily lives.

The personality–job mismatch was also exhibited in the perceivers' spinal loading responses to the experimental task. The general trend was that the higher compressive and shear forces on the spine occurred in perceivers rather than in judgers regardless of moment and, often, lift frequency. Perceivers enjoy changing situations, whereas judgers are comfortable with keeping to a set plan of work [6]. The experimental task seems more matched to the judgers' preferences. Interestingly, for this personality group, significant differences between the personality types were primarily exhibited only in the experienced workers. In fact, novice perceivers and novice judgers responded to the experimental conditions with statistically similar spinal loading levels. Additionally, even with several years of MMH experience, experienced perceivers acted similarly in terms of compressive and shear spinal loading as the novice workers. Marras et al. [7] suggested that during low physical demands, psychosocial stress may manifest itself by increasing muscular requirements. They further suggested that during high physical demands, the physical requirements may negate the stress-induced increase in muscle activity. Again, although the current experiment did not purposively induce psychosocial stress upon the subject, the findings may be relevant to those of previous studies. It may be that because of their experience with MMH activities, the experimental task, regardless of moment or frequency level, imposed less physical demands on experienced subjects than their typical MMH duties, and the psychological stress was therefore discernible in the perceivers. Novices, on the other hand, were not experienced with this labor, and as such, the physical demands negated any psychosocial stress responses. This suggests that the personality type of a worker, when incorrectly matched with the job requirements, could affect the motor control learning that should otherwise increase as MMH experience increases.

There were several potential limitations in this study. First, although the reliability [10] and validity [11] of the MBTI have been reported, this personality assessment has primarily been used to assess "white collar" workers and only seldom for physical labor [7]. Because of its simplicity and minimal subject time commitment, the MBTI assessment was employed in this study. Second, subjects were not recruited on the basis of personality type, so the balance between all four MBTI categories was not even in all cases (introvert/extrovert and feeler/thinker). Future studies should recruit subjects such that the necessary balance exists and all personality traits can be studied. Third, in order to better understand the influence that the personality–job match phenomenon has on spine biomechanics, jobs with different characteristics should be studied. Finally, even though work experience was a factor in this study, the findings of this study must not be misinterpreted to make judgments about the appropriateness of worker training. We did not examine the degree of training or even if our experienced subjects were exposed to training.

In conclusion, the findings from this study provide evidence that spinal loading may increase when the personality preferences of an individual are not matched with the task requirements of a job. This phenomenon may also manifest itself in terms of motor control development in that motor skill learning that normally occurs with MMH practice may be hindered as a result of a personality–job mismatch. Further research is needed, however, to determine that motor control development is different between these and other personality types.

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