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Research Article

Transient Low Back Pain among Helicopter Pilots; Imaging and Lumbar Trunk Muscular Endurance

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Abstract

Background

Low Back Pain (LBP) related to flying is common among helicopter pilots. This pain may influence flying performance and it is therefore important to better understand this problem. The aim of the study was to examine if flying related transient LBP is associated with occupational factors and/or Lumbar Trunk Muscular Endurance (LTME) and/or imaging of the Lumbar Multifidus Muscle (LMM).

Methods

58 male helicopter pilots with transient LBP were investigated for clinical and other pain aggravating factors. LTME was timed in 4 positions. Isometric contraction of the LMM was measured by ultrasound along with MRI examination.

Results

The pilots with mean age of 39.6 (SD 7.5) had extensive flying experience. 57% of the pilots reported transient LBP > 5 years. Mean VAS and ODI was 3.2 (SD 1.9) and 10.1% (SD 5.8). 90% of the pilots reported sitting-time in cockpit important for LBP symptoms. The pain affected flying performance for 29%. The pilots achieved unexpectedly low mean LTME in the 4 positions. MRI and ultrasound measurements provided no additional information concerning transient LBP.

Conclusion

Transient LBP related to flying among helicopter pilots are common, low in intensity and may affect flying performance. The pain was aggravated by prolonged awkward constrained sitting and intensified with duration. Reduced LTME may be suggestive for transient LBP.

Keywords: Fat-infiltration; Lumbar multifidus muscle; Muscular contraction; Prolonged sitting

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Introduction

Non-specific Low Back Pain (LBP) defined as pain not attributable to a recognizable, known specific pathology in the lumbar area, has become a major public health problem. Lifetime prevalence is reported to range between 60-85% [1]. In 10-15 % of patients acute LBP develops into chronic back pain [1]. Recurrence is a distinctive feature of LBP [2] and most episodes are self-limiting and not related to serious disease [1].

Several studies [3-5] have shown that LBP is frequent among helicopter pilots and the pain is described as transient and/or recurrent. Transient LBP, related to flying exposure, is characterized as temporary, dull and non-radiating in nature. This pain has onset during flying and ceases some time after flying. Back pain, while piloting, may affect flight performance and safety. This may reduce operational effectiveness and lost duty time, occupational attrition as well as performance deficits during critical phases of flights [3].

The lumbar trunk consists of passive (spine, pelvis, fascia and ligaments) and active structures (muscles). All of these structures acts synergistically to stabilize the lumbar spine [6] and they all facilitate motion of the lumbar trunk in combination of multiple directions of flexion, lateral flexion, rotation and extension whether one is sitting, standing, lifting or rolling over in bed [7].

Reduced Lumbar Trunk Muscular Endurance (LTME) in extension, flexion and side bridge are considered predictive of either having or being in danger of developing LBP [6]. Especially lumbar extension muscle tests have been utilized to evaluate lumbar trunk endurance among healthy people or LBP sufferers with a chronic or recurrent pattern [6,8,9].

The paraspinal lumbar trunk extension muscles consist of iliocostalis lumborum, longissimus thoracis and the deep and superficial portion of the Lumbar Multifidus Muscle (LMM). Reduced size of paraspinal musculature is found in chronic LBP sufferers [10]. Atrophy and fat replacement of the LMM itself is related to LBP [11]. Reduction and loss of function in contraction of the LMM has been measured by the use of Ultrasound (US) [12] and the muscle has been evaluated for fat degeneration and atrophy by Magnetic Resonance Imaging (MRI) [13,14]. Temporary periods of symptomatic improvements from LBP may not improve the LMM function [15].

To obtain more information on transient LBP related to flying among commercial helicopter pilots we have examined occupational factors during flight that may be associated with the occurrence of pain. Likewise, we have investigated the pilots' LTME and performed imaging of the LMM as well as MRI examinations of the lumbar spinal area to explore possible associated factors.

Methods

Participants

During March through June 2013 we invited, by mail, all the commercial pilots (313) in the two largest helicopter companies Canadian Holding Company (CHC) and Bristow Norway to participate in a retrospective questionnaire-based study to investigate the occurrence of spinal pain. Among the 242 pilots returning the questionnaires, we had to exclude the pilots with cervical and thoracic pain. For the remaining 207 pilots, 103 reported transient LBP, defined as lumbosacral pain in at least one of three flights last month. Due to logistical, economical and practical reasons, 83 pilots (76 men and 7 women) from the companies bases in Bergen and Stavanger were eligible for further examinations. Because of the small sample size of female pilots, we decided to exclude them from the analysis.

Despite several reminders, 14 pilots did not respond to the invitation. In addition, five pilots refrained from further participation and one pilot had moved out of the area. Hence, the letter of consent to participate was signed by 58 male pilots. They made up the total study population satisfying the inclusion criteria of a transient pattern of LBP, related to flying, in the area between lower ribs and the gluteal folds. There were no other exclusion criteria for these medically licensed fully operative pilots. The Western Norway Regional Committee for Medical and Health Research Ethics approved the study protocol (REK Vest 2010/2254).

Pilots from the two involved companies are responsible for the shuttling of personnel to operate the oil installations along the Norwegian coastline. The helicopter pilots are full time employed and work in rotation schemes where the longest working period consists of 14 consecutive flying days followed by a similar free period. Both companies operate the Eurocopter EC 225 Airbus and Sikorsky S92. In addition, CHC operates the Eurocopter AS332 L/L2 Superpuma.

Questionnaires

The pilots answered questions regarding duration, location, exacerbating and alleviating factors of the pain, including the role of ergonomics and body mounted equipment as well as questions regarding pain patterns during the flight. Average intensity of the LBP last week, whether flying or not, was evaluated by Visual Analog Scale (VAS, 0-10). The questionnaires also included impact of LBP on function using the Oswestry Disability index (ODI; 0-100) and the EuroQol-5D questionnaire for health-related quality of life (a profile with a single index, 0-100, with 100 as best possible). All questionnaires were filled out at the time of the clinical examination.

Examinations

The study comprised of clinical examinations, muscular endurance tests, US measurements of the LMM, and MRI of the lumbar spine.

The clinical examination of the lumbosacral spine comprised of standard orthopedic/neurological examinations testing for reflexes, strength, and sensitivity with nerve stretching tests as well as evaluation of range of motion.

Further the pilots were tested for LTME, without tactile or verbal feedback, in extension, flexion and side bridge on either side as described by McGill [6] (Appendix 1). The endurance tests were arbitrarily conducted by either the main author or a physiotherapist after initial consensus of test procedures and measurement endpoints.

When performing the prone arm-lifting task, without loading, the pilots had a real-time US measurement of the isometric contraction of the contralateral LMM. This was done in a longitudinal view at the apex level of the facet joints between L4-5 and L5-S1 on both sides as described previously [16]. Applying on-screen calipers, the ability to contract the LMM was measured in mm of thickness, and given as percentage increase from relaxed to contracted, measured separately on both levels and both sides. (Samsung Medison Accuvix XG, 3366 Hanseo-ro, South Korea for the Stavanger population and Medison SonoAce 8000 EX, 3366 Hanseo-ro, South Korea for the Bergen population, using a 3-7 MHz curvilinear probe on both machines).

After the clinical examination, the pilots were offered an MRI examination of the lumbosacral spine. Due to various reasons, such as other treatments, previously performed MRI or non-responders, 38 male pilots completed a standard MRI scan at Stavanger University Hospital, Department of Radiology (Philips Achieva 1,5T NOVA Software: release 2.6.). Technical difficulties with the MRI machine made the T1 images of one pilot invalid. A total study group of 37 male pilots had standardized lumbosacral MRI examinations.

MRI scans elicited information regarding discal height and dehydration and pathology as prolapsed discs with size and location. In addition, the radiologist registered any presence of Modic changes with type and location. These are end plate and bone marrow changes adjacent to degenerative intervertebral disc representing a possible process from bacterial infection with edema to subchondral sclerosis.

T1 weighted MRI scans of the lumbosacral spine in transverse plane allowed for quantification of square area and fat content of the LMM. In applying the OsiriX MD Dicom, FDA-Cleared / CE IIa reader program (Geneva, Switzerland) image processing software, the circumference of the LMM was delineated with measurement of the square area as well as analysis of the mean gray tone scale values at the vertebral levels of L4-5 and L5-S1 bilaterally. This was performed on 4mm slice-thickness projections at the level of and through facet joints parallel to the discs at the same level as the US measurements of the LMM. On Dicom images, higher mean grayscale values (0:1000 = black: white) reflect increased whiteness in relation to increased fat content. After procedural agreement, two of the authors (KA, GD) performed two individual and separate measurements with 2 week intervals. Mean greyscale values and square areas of the LMM were calculated based upon combination of the two authors' individual measurements according to level and side.

Statistics

Descriptive statistics are given as means and Standard Deviations (SD) for continuous data and as counts and percentages for categorical data. Confidence Intervals (CI) for means are based on the normal approximation. Correlations were estimated non-parametrically using Kendall's tau (τ). All statistical analysis was performed applying IBM SPSS Statistics v. 23. Statistical significance was defined as $p<0.05$.

Results

Table 1 shows demographic, flying related and clinical characteristics of male helicopter pilots reporting transient LBP between the 12th rib and gluteal fold when flying.

Frequency, intensity and provoking factors of transient pain

Among all the pilots reporting the transient LBP pattern, 57% of the pilots had experienced this pain for more than 5 years. Half the

Age (years)	39.6 (7.5)
Height (cm)	182 (6.2)
Weight (kg)	85.4 (9,3)
BMI	25.5 (2.1)
VAS[1]	3.2 (1.9)
ODI[2] (%)	10.1 (5.8)
EQ-5D[3]	84.1 (12.4)
Flying experience	
Years	14.6 (7.9)
Total hours	5930 (3490)
Hours last year	541 (179)
Minutes per day	329 (30)
Hours in "large" helicopter	3860 (2900)
Aircraft	
AS332 L / L2	8 (14%)
EC225	2 (3%)
S92	48 (83%)

Table 1: Demographic data for male commercial pilots with transient low back pain. Results given as means (SD) unless otherwise stated as N = 58.

[1]Visual Analog Scale of LBP and pelvic pain last week (0-10).

[2]Oswestry Disability Index in % (0-100) on effect of pain on daily living at the time of the examination.

[3]EQ-5D, self-reported score of status of health at the time of the examination.

study population had never been on sick leave over the last 5 years. Only 8 (14%) pilots had 3 or more sick leaves due to LBP over the last 5 years. As few as 9 pilots (16%) reported a total combined duration of absence due to LBP of more than a month over the last 5 years.

VAS on intensity of "LBP last week" had a mean value of 3.2 (1.9), and showed that 36 pilots (62%) scored VAS between 0 and 3. Nineteen pilots scored VAS between 4-6 and only 3 pilots scored seven and above. On the ODI only three pilots scored above 20% and one-third (34.5%) of the pilots scored maximum value 100 on EQ-5D.

Mean daily flying time during working periods was 329 (SD 30) minutes per day per pilot. Ninety percent of the pilots reported that sitting time in the cockpit seat was important for the development of transient LBP. More than half of the pilots experienced the pain within 2 hours of flying, which constitutes less than half of their mean daily flying time. Similarly, the intensity of the pain was related to the time spent in the cockpit seat. About half of the pilots related pain also to the body mounted life jackets and the constrained sitting in the cockpit. About 1/3 thought that vibration could cause the pain. The design of the aircraft seat with upholstery and lack of possibilities for regulation of the seat was reported as a provoking contributor to LBP by 74% of the pilots. As many as 17 pilots (29%) reported that the pain situation affected their flying performance and 10 pilots (17%) reported this in 1of 5 sorties or more frequently.

Clinical findings and muscular endurance

Standard orthopedic and neurological examination revealed no findings consistent with a radicular pain patterns. LBP on Valsalva maneuver was reported by 6 pilots along with minor limitations and low-grade pain in corresponding anatomical area upon examination of lumbar trunk range of motion.

Among the male helicopter pilots in the present study, all non-smokers, 93% reported to do physical training of at least 30 minutes' duration on a weekly basis. Over 80% of the pilots declared 2 or more sessions per week and 46% reported to do specific exercises for the low back. The pilots achieved a mean endurance time, on extension test, of 50 seconds ranging from 7 to 117. Similarly, on flexion test, they scored 72 seconds ranging from 9 to 240. On the right and left side bridge they managed a mean of 38 and 41 seconds ranging equally on respective sides from 10 to 120 seconds.

These fully employed and operative commercial pilots had generally weaker performance on LTME tests compared to results from other studies applying similar testing procedures. These studies involve both non-affected and LBP affected male populations of comparable age groups. They scored, on the extension test, half of the mean values compared to fully operative Swiss army helicopter pilots. In comparison to asymptomatic blue collar workers, with a history of LBP and a "physically demanding work", the pilots scored 65% of the mean values on the respective side bridge tests [17]. Compared to healthy males from a university setting, although younger, the pilots scored less than half of the mean value on the flexion test and 52-58% on the side-bridge and extension tests (Table 2).

	EXT	FLEX	RSB	LSB
Commercial helicopter pilots, this study Males, n = 58, age 39.6 (SD 7.5) Transient LBP pattern No encouragement during testing	50 (43.2 to 56.8)	72 (60.7 to 83.3)	38 (32.7 to 43.3)	41 (35.7 to 46.3)
Army helicopter pilots [18], Males, n = 36, age 33.1 (SD 7.6) Unknown health status Tactile feedback during testing	≈ 100 *	≈ 75*	≈ 56* Side bridge, one side only, feet against support	
University volunteers [2] Males, n = 40, age 31.8 (SD 10.7) Healthy No encouragement during testing	96 (81.8 to 110.2)	158 (133.3 to 182.7)	68 (59.8 to 76.2)	70 (61.5 to 78.5)
Blue collar workers [12] Males, n = 22, age 41 (SD 6) History of LBP, asymptomatic at test time No encouragement during testing	90 (69.2 to 110.8)	84 (64.2 to 103.2)	58 (48.2 to 67.8)	65 (53.5 to 76.5)
Industrial manual workers with LBP [16] Males, n = 24, age 38.79 (SD 9.24) Low back pain, included if VAS < 3 Encouragement unknown	121 (103 to 139)	Not performed		
Industrial manual workers without LBP [16] Males, n = 21, age 38.24 (SD 9.33) Control subjects, no LBP Encouragement unknown	168 (153.6 to 182.4)	Not performed		

Table 2: Measurements of lumbar trunk muscular endurance among male pilots in 4 isometric positions [12]. Results in seconds, given as means with (95% CI).

Referenced comparable studies describing subjects, sex, number of participants, age (mean and SD), health status if given and type of feedback during testing. Four lumbar trunk muscular endurance tests; EXT = Extension, FLEX = Flexion, RSB = Right Side Bridge, LSB = Left Side Bridge.

*No (SD) given

Ultrasound and MRI findings

Table 3 shows ultrasound measurements of the differences in percent of the isometric contraction of the LMM muscle at vertebral levels L4-5 and L5-S1 on either side and in combination of levels and

		Difference in isometric contraction[1] measured by Ultrasound n = 58	Mean greyscale values[2] measured on MRI/OsiriX MD Dicom n = 37	Kendall's τ (p-value) n = 37
Separate	Left L4-L5	9.4 (6.7)	295.6 (91.6)	-0.18 (0.12)
	Right L4-L5	8.7 (6.6)	286.7 (86.2)	0.02 (0.88)
	Left L5-S1	6.7 (5.2)	559.3 (98.2)	-0.07 (0.53)
	Right L5-S1	5.1 (4.3)	562.5 (81.8)	-0.01 (0.93)
Level	Left L4-L5 + Right L4-L5	9.0 (5.8)	291.1 (87.2)	-0.04 (0.71)
	Left L5-S1 + Right L5-S1	5.9 (4.2)	560.9 (87.0)	-0.07 (0.57)
Sides	Left L4-L5 + Left L5-S1	8.0 (5.7)	427.5 (75.1)	-0.12 (0.30)
	Right L4-L5 + Right L5-S1	6.9 (5.1)	424.6 (68.3)	0.03 (0.81)
Combination	Both levels/Both sides	7.5 (4.8)	426.1 (69.8)	-0.05 (0.66)

Table 3: US measurements and MRI/OsiriX MD Dicom mean grayscale values. All values in means (SD).

US measurements of difference in percent between relaxed and isometric contracted LMM calculated on longitudinal view at apex of L4-L5 and L5-S1 facet joints. MRI/OsiriX MD Dicom means grayscale values measured on T1 images of square area of the LMM at the level of the apex of facet joints at L4-L5 and L5-S1. Separate measurements at levels L4-L5 and L5-S1 on either sides and in combination.

[1]Ultrasound measurement: no difference in contraction = 0%, Expected range in difference in contraction; ≈ 0-20%

[2]MRI/OsiriX MD Dicom greyscale values black: white = 0:1000. Increasing fat content with increasing values.

sides. The smallest difference and consequently the poorest isometric contraction were at level L5-S1. About half of the pilots showed isometric contraction of less than 5% at this level. At level L4-L5, a third of the pilots had less than 5% difference in contraction. There was, however, no correlation between degree of impaired contraction and level of experienced LBP as measured by either VAS or ODI.

Among the 58 male pilots with a transient LBP pattern included in this study, 37 pilots also had a standard MRI examination of the lumbar spine. In comparing segmental levels L4-L5 versus L5-S1 among these 37 pilots, we found disc dehydration on 35% versus 51%, reduced disc height on 13% versus 40% and a bulging disc or a prolapse on 30% versus 46%. Nerve compression was detected in two pilots at level L4-L5 and in 3 pilots on level L5-S1. Only two pilots showed evidence of degenerative changes at L3-L4. One pilot had Modic type 1 change at L5-S1. Modic changes type 2 was found in one pilot at level L4-L5 and in 7 pilots at level L5-S1. None of the pilots had type 3 Modic changes. MRI/OsiriX MD Dicom mean greyscale value at level L5-S1 showed 52% higher value indicating increased whiteness i.e., increased fat content compared to L4-L5. Again there was no correlation between increased whiteness, representing fat degeneration of the LMM, and level of experienced LBP as measured by either VAS or ODI.

Association between muscular endurance, Ultrasound and MRI/Osirix MD findings

The correlations between muscular endurance of the lumbar trunk, irrespective of testing position, and mean grayscale values of the LMM, as well as between muscular endurance and ultrasound measurements of the isometric muscular contraction were investigated. There was a small correlation between difference in isometric muscular contraction and LTME. However, only the finding between lumbar levels L4-L5/L5-S1 on the left side and right side bridge test was statistically significant. There was no correlation found between MRI/OsiriX MD Dicom findings and LTME (Table 4).

Discussion

This study shows that flying related transient LBP among commercial helicopter pilots is low to moderate in intensity. The majority of the pilots experience the pain within the first half of their working day and the pain was intensified by flight duration and time in the cockpit seat. One third of the pilots reported the transient LBP to affect their flying performance and for a portion of the pilots as often as at least in one of five sorties. The main finding from clinical and imaging examinations, in spite of high level of physical activity among the pilots, was surprisingly low scores on LTME tests. Based on this finding we hypothesize a relationship between constrained sitting, reduced muscular lumbar trunk endurance and transient LBP when flying. Interventions to strengthen muscular endurance could possibly reduce this important issue among the pilots.

Transient LBP is a frequent and important complaint among commercial helicopter pilots. Radicular symptoms are rare [3,19]. The majority of the pilots in our study had experienced these low-grade transient pains during a third of their working career. Despite the duration and frequency of the LBP, absence or sick leave prescribed by health professionals were rare and of short duration. After completion of a flight most pilots experience pain reduction.

Previous studies regarding LBP among helicopter pilots have suggested numerous causal factors. However, such factors are difficult to establish versus several associated factors that can be related to the individual pilot, safety equipment, prolonged sitting and posture, effects of vibration and ergonomic design of the cockpit including design of the seats.

In general, pilot related anthropometrical factors are not considered relevant for the presence of LBP among the rotary wing population [3]. Previous history of back injury has been found to be a significant predictor [5]. Mandatory body mounted equipment for safety including the life vest and emergency radio beacon are reported by half of the pilots in this study as a factor in conjunction with sitting constrained in the 5-point harness. In addition, posture and sitting position are frequently listed as a possible cause. The commercial pilots in this study had a mean daily flying time of 5 hours and 29 minutes. Nearly all the pilots considered sitting in the cockpit seat as important for developing transient LBP and the pain intensity was increasing with longer duration of sitting. Of note these pilots apply automatic flight control system for the majority of the cruising time and fly manually during take-off and landing.

	Vertebral Level/Side	EXT	FLEX	RSB	LSB
Ultrasound, mean value of difference in contraction n = 58	L4-L5 / left + right	0.00 (0.99)	0.15 (0.10)		
	L5-S1 / left + right	-0.04 (0.66)	0.11 (0.23)		
	L4-L5 + L5-S1 / left side			0.23 (0.01)	
	L4-L5 + L5-S1 / right side				0.02 (0.83)
	Both levels / Both sides	-0.01 (0.91)	0.15 (0.10)	0.15 (0.10)	0.11 (0.25)
MRI/OsiriX MD Dicom, mean grayscale values	L4-L5 / left + right	-0.09 (0.46)	0.02 (0.88)		
N = 37	L5-S1 / left + right	0.03 (0.82)	-0.05 (0.68)		
	L4-L5 + L5-S1 / left side			0.06 (0.63)	
	L4-L5 + L5-S1 / right side				-0.09 (0.46)
	Both levels / both sides	-0.03 (0.80)	0.00 (0.98)	0.05 (0.68)	-0.10 (0.38)

Table 4: Correlation1 between results of LTME2 with US3 and MRI/OsiriX MD Dicom4 measurements the LMM.

[1]Correlations given as Kendall's τ with (p-value). [2]LTME; Lumbar Trunk Muscular Endurance tests [6] measured in seconds in 4 isometric positions; EXT = Extension, FLEX = Flexion, RSB = Right Side Bridge, LSB = Left Side Bridge. [3]US; Ultrasound measurements of difference between relaxed and contracted LMM. [4]MRI/OsiriX MD Dicom mean grayscale values for T1 images (black:white = 0:1000) representing low to high fat content of the LMM.

Sitting on its own is not considered as correlated to the occurrence of LBP [20]. A previous study has, however, identified a correlation between increased time spent sitting, physical inactivity and poorer back extension muscle endurance among LBP subjects with increased posterior tilt in sitting [18]. In addition, a study among helicopter pilots with co-exposure to both prolonged awkward sitting and vibration showed a fourfold increase in the risk of LBP compared to sitting on its own [4]. Maintaining a static posture during two hours of sitting is bearable but there is also a need to alter the lumbar angle on a frequent basis as the human body requires movement to avoid injuries [6]. Movement provides periodic rest for the muscles [21]. Prolonged static postures lead to muscle fatigue and muscular imbalances [21]. This observation is supported by another study of pilots that states that the primary causal factor for flight related pain is posture and fatigue due to extended periods of static position [22]. The pilots' possibilities for accommodations and sitting adjustments in the cockpit seat are restricted by the 5-point harness and the obligatory body mounted safety gear during the 329 minutes of daily flying time. Thus, the rather long and simultaneously constrained sitting seems to be important for the transient LBP when flying.

Lumbar trunk endurance varies with sex, age, Body Mass Index (BMI), motivation, self-efficacy, previous history of LBP and levels of activity and physical exercise [6]. Several studies have explored the role and link between decreased isometric lumbar trunk extension endurance and chronic LBP [9]. Isometric lumbar trunk extensor endurance also discriminates between healthy individuals and patients with low back pain and it may predict later occurrence of LBP [9]. Studies have shown that less than 176 seconds on the extension test predicted LBP during the following year and a value above 198 seconds predicted absence of LBP [9]. Other studies state that extension endurance less than 58 seconds is associated with a 3-fold increase in the risk of LBP [9]. Exercising 30 minutes per week, and more frequent and intense exercise in the past year has significant associations with longer endurance times [23]. In this study, 93% of the pilots reported that they did physical activity of at least 30 minutes' duration 3 times per week and nearly half of them did exercises for their lumbar trunk and low back. Still they score between 55 and 65% of values scored in extension and side bridges by asymptomatic workers with a history of LBP and even less compared to healthy individuals. The reduced LTME, and especially of the extensor group, among these pilots may be important for their flying related transient LBP.

MRI examinations of the pilots in this study revealed degenerative changes for half of the pilots at lumbar level L5-S1. Lumbar level L5-S1 was more affected than level L4-L5 on all analyzed MRI variables. As for the general population, pathology evidenced by imaging does not necessarily correspond with pain or functional deficits [3].

Increased fat-infiltration of the LMM and a corresponding reduced isometric activation of this major lumbar stabilizing muscle could have influenced and affected lumbar trunk endurance. In the present study population reporting low intensity pain, we could not detect correlation between mean greyscale values subsequent to fat infiltration on the T1 weighted MRI scans and muscular endurance in any of the 4 tested positions. This is consistent with one study [14] and in contrast to another [24]. On US examinations we found a small correlation between differences in isometric muscular contraction, measured in the LMM on a combination of lumbar levels and corresponding sides at L4-L5 and L5-S1, and LTME. However, a statistical significant finding was found only between contraction ability in lumbar levels L4-L5/L5-S1 on the left side and the results for the right-side bridge test.

Taken together, the findings from this study, point to prolonged constrained awkward sitting position as an important factor in provoking transient LBP. In addition, other studies link reduced LTME [6] and especially deconditioning of the lumbar muscular extensors to LBP [9]. We therefore hypothesize that prolonged awkward and constrained sitting and reduced LTME both may provoke the observed transient LBP in helicopter pilots.

In support of this hypothesis studies focusing on stretching and strengthening low back musculature among aircrew members have been performed [25,26]. A study of Swiss army helicopter pilots reported the dorsal extensor group as the weakest and assigned a personalized short exercise program for the pilots. They reported improvement of lumbar trunk endurance in a one year follow up without any information regarding pain [26].

Limitations of this study include retrospective collected data on pain occurrence, frequency and intensity while flying and must be interpreted with caution. Psychosocial variables have not been evaluated in this study. Further, our study did not include a control group measuring the endurance tests, but we had to rely on comparison with previous studies indicating a reduced LTME among the pilots. Strength of this study is the extensive aviation experience in years and hours among this group of pilots. On the other hand, we cannot disregard a temporal self-selection by pilots who do not tolerate this type of occupational exposure and therefore earlier in their careers seek other working assignments as pilots.

Conclusion

Helicopter pilots are affected by transient LBP related to flying. The pain is seldom radiating in nature and it ceases some time after flying. The transient pain may affect flying performance with increased flight duration. Prolonged awkward constrained sitting posture may contribute both to pain and its intensity. Reduced LTME may be suggestive for a transient LBP pattern related to flying. The effects of structured training regimens on LTME and transient LBP should be investigated.

Supplementary Information

Test of Lumbar Trunk Muscular Endurance (Appendix 1).

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Authors Declaration

The authors declare no conflict of interest.

Data Deposition

The secured Research Server at Stavanger University Hospital, Stavanger, Norway stores the data collected for this study.

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Appendix 1

Testing procedure for lumbar trunk muscular endurance [1]

Equipment: Angle bench, floor mat, 55° angled jig (equipped with anti-skid material on the bottom) and stop watch

General Instructions: This is to measure in seconds your lumbar trunk muscular endurance in 4 positions; extension, flexion and side-bridge on either side. The purpose is to measure how long you can maintain a steady posture in each position and the time starts once you are guided into the correct position and you say a clear and loud YES. You can stop whenever you like. You will not receive any verbal or tactile feedback during the test. If you deviate from the assigned position I will stop the test. You will be allowed some movement. (Intertester agreement allows 5 cm). There will be at least a 3 minute rest between the different tests.

Test 1 Extension

Bench settings: Horizontal foot piece. Chest piece lowered to 60° to give some support during positioning only.
The candidate is placed prone on the angle bench with feet securely fastened under the foot support. The body is placed with anterior superior iliac crest cantilevered on the superior edge of the tables foot piece, Hands and arms crossed on opposite shoulder in front of the chest. Candidate lifts the upper torso and is guided to a straight body line.

Test 2 Flexion

Bench settings: The entire bench is horizontal. The jig is put on top and position is adjusted to the length of the individual test person.

The candidates sit on top of the bench with feet firmly secured under the foot support with a knee angle of 90°. The upper torso is leaned against the 55° angled jig. The candidate is instructed to maintain that 55° angle according to general instructions as outlined above. The test starts when the jig is pulled back 10 cm.

Test 3: Side bridge on either side.

Right side up first as a procedure.

Floor mat: The candidate is placed sideways on the mat with straight knees and upper leg in front of the lower with toe against heel. Upper body is supported with elbow on the floor resting free hand supporting the weight-bearing opposite shoulder. The test starts once the body is in a straight line.

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