Pilots After Shoulder Surgery and Rehabilitation in a Dedicated Musculoskeletal Rehabilitation Unit of a Major Airline Returned to Work Earlier When Compared to Standard Rehabilitation by External Providers

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Purpose: The purpose of this study was to compare the time to return to work (RTW) for pilots who underwent shoulder surgery and underwent rehabilitation within a dedicated musculoskeletal rehabilitation (MSK) unit of a major airline to a group of pilots who had standard rehabilitation and to calculate cost savings. **Methods:** The database of Emirates Airline was searched for all ICD-10 codes relating to shoulder pathology. Pilots who had shoulder surgery between January 2017 and June 2021 were included. Pilots who had previous shoulder surgery, underwent fracture surgery, joint replacement, revision surgery, or conservative treatment were excluded. The time between suspension and reinstatement of their license was defined as RTW. Cost savings were calculated on the basis of the median salary and rosterable fraction of a commercial airline pilot. RTW compared between a group undergoing rehabilitation in the MSK unit and a group receiving standard rehabilitation by external providers. Group allocation for either attending MSK unit or standard rehabilitation occurred randomly and according to the individual pilots preferences. **Results:** The MSK unit treated 36 pilots (36 males/0 females, mean age 45.4 ± 9.4), and 18 pilots (17 males/1 female, mean age 50.3 ± 7.3) were treated by external physical therapist providers. Patients treated by the MSK unit returned to work at a mean of 85.3 ± 32.8 days, and patients treated by external providers returned to work at a mean of 117.9 ± 42.5days ($P = .02$). The cost savings for pilots treated by the MSK unit were calculated to be $27,948 USD per patient. **Conclusions:** The results of this study showed that pilots' after shoulder surgery RTW times range between 85 to 118 days. Rehabilitation in a dedicated MSK unit reduced the return to flying duties by 39%. Pilots treated by the MSK unit returned to work by a mean of 33 days earlier with cost savings of $27,948 USD per pilot.

The functional demands on the upper extremity in aircrew are high, and regular overhead activities require dexterity, strength, and endurance.[1] Page et al.[1] demonstrated that average abduction movements of 125°, external movements of 75°, forward elevation of 100°, and internal rotation of 50° are required to complete various cockpit tasks. In general, the available subacromial space is minimized at 90° of humeral elevation in all planes.[2] However, the rotator cuff tendons are in contact to the undersurface of the lateral acromion at 45° of abduction already, but, with angles beyond 60°, the rotator cuff footprint has already cleared the under surface of the acromion and the classical impingement pain at 90°, most likely because the rotator cuff torque is the highest.[3] These ranges are within the required functional demands of pilots, and shoulder pathology may result in reduced functional capacity. For example, the Federal Aviation Authority stresses that any musculoskeletal condition that makes someone unable to safely perform the duties must not be granted medical clearance, which will result in either suspension or cancellation of the license.[4]

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Shoulder related disorders are common in pilots. Tegern et al.[5] showed that the 1-year prevalence in fighter and helicopter pilots aged between 34 to 39 years accounts for 20% to 26% of all musculoskeletal disorders compared to 12.5% for army soldiers.[5] The prevalence of shoulder pain is associated with age, and higher figures can be expected in older pilots. Luime et al.[6] reported a prevalence of shoulder pain in the general population of 8% in 35- to 44-year-old individuals, 15% in 45- to 54-year-old individuals, and 27% in 55- to 64-year-old individuals. The mean time to return to work after shoulder surgery has been reported to range between 7 to 9 weeks, but the mean time for manual workers has been reported to be 3 months.[7,8] Regulatory bodies such as the European Union Aviation Safety Agency and the Federal Aviation Authority have issued explicit functional criteria for pilots and cabin crew, and return to light duties is not an option for this population.[4,9]

The purpose of this study was to compare the time to return to work (RTW) for pilots who underwent shoulder surgery and underwent rehabilitation within a dedicated musculoskeletal rehabilitation (MSK) unit of a major airline to a group of pilots who had standard rehabilitation and to calculate cost savings. It was hypothesized that pilots who were treated by the dedicated rehabilitation unit would return to work earlier.

Methods

This study was designed as a retrospective study of prospectively collected data. Pilots were included if they underwent shoulder surgery between January 2017 and June 2021 for the following surgical procedures: rotator cuff repair with and without subacromial decompression, arthroscopic subacromial decompression, Bankart repair for anterior shoulder instability, and SLAP repair including biceps tenodesis. Pilots who had previous shoulder surgery, underwent fracture surgery, joint replacement, revision surgery, or conservative treatment were excluded. Combined procedures such as rotator cuff repair and biceps tendon surgery and Bankart repair with remplissage or bone grafting procedures such as glenoid bone grafting and Latarjet surgery were excluded. The database of the General Civil Aviation Authority (GCAA) was used and searched using shoulder surgery—related ICD-10 codes. The GCAA is the federal body overseeing all aviation-related activities in the United Arab Emirates. The GCAA CAR MED regulations outline the medical provisions for licensing pilots and cabin crew.[10] In chapter 5 the physical and mental requirements for licensing are described. If air personnel are determined unfit to fulfill the privileges of their license, the responsible aviation medical physician will request suspension of the license.[10] Once the request is uploaded onto the GCAA website, the license will be suspended with immediate effect. For medical conditions, a detailed medical report will also be submitted to the GCAA that includes all applicable ICD-10 codes. Similarly, for reinstatement of the aviation license, the responsible aviation medical physician will upload a request for reinstatement. This request again includes all applicable ICD-10 codes, all applicable medical reports, and detailed operation notes from the treating specialist.

The database was searched by an aeromedical officer of the GCAA for the following ICD-10 codes: M75.00, M75.30, M75.40, M75.50, M75.110, M75.120, S42.023S, S42.123D, S42.209S, S43.50XD, S43.006D, S43.109S, S43.396D, S43.429S, S43.439D, and S46.019D. These codes were selected by one of the senior authors (R.J.P.) and was based on the practices of the musculoskeletal rehabilitation unit of Emirates Airline. These codes were uniformly applied to all shoulder conditions. It is acknowledged that this approach may have missed aircrew from other airlines, but the possible selection bias was considered to be minimal. The extracted data were deidentified by the GCAA and presented to the research team. The following variables of interest were documented: age, sex, seniority (first officer, captain), experience, detailed medical history including previous treatments, deidentified operation reports and postoperative rehabilitation, and date of license suspension and reinstatement. The findings were then compared to the database from the Musculoskeletal Rehabilitation Unit of Emirates Airline. Pilots decided whether they would prefer rehabilitation in the MSK unit or being treated by their preferred external physiotherapist.

MSK Unit Rehabilitation Protocol

The MSK unit used a multidisciplinary approach for all patients. Before the scheduled surgery the pilots will be assessed by the treating aeromedical musculoskeletal physician, physical therapist, and other providers such as psychologists and occupational therapists if required. The team will inform the pilot about expected time frames and functional assessments required to safely return to work and safely operate an aircraft. For example, the expected range of motions to reach overhead switches, oxygen masks, and operating the airplane on the ground (use of the tiller) and in the air (yoke or joystick) are discussed. The functional assessments are task specific and aim to train the pilots for the tasks required. In addition, specific strength training for the upper extremity is implemented. Here, a minimum of 50 pounds of peak force is required to operate the yoke in emergency conditions. After surgery, pilots are treated twice weekly by the physical therapist; a home program is prepared, and the pilots have free access to the rehabilitation gymnasium for training. because this is the same gymnasium the physical therapist operates and uses for treatment, there is the opportunity for the

Table 1. Shoulder Rehabilitation Protocol applied at the MSK Unit

Time Frame	Manual	Exercise	Goals	Amendments/Comments
Weeks 0-2	Soft tissue mobilizations of surrounding soft tissue for edema Gentle PROM	1. Pendulum 2. Squeeze ball 3. Triceps & Biceps Thera Band 4. Pulley passive flexion 5. Isometric abduction, adduction, extension and flexion 6. Scapular setting and activation of scapula muscles	1. Decrease pain & edema 2. PROM 0° to 60° 3. AROM elbow flexion/extension 4. Sling use for 4 weeks	1. Restricted combined abduction and external rotation (0-6 weeks) 2. External rotator cuff repair—Avoid restricted external rotation and internal rotation stretch (0-6 weeks) 3. Internal rotator cuff repair (Subscapularis)—Avoid restricted internal rotation and external rotation stretch (0-6 weeks) 4. SLAP repair—avoid isolated resisted elbow flex (0-6 weeks) 5. Bicep tenodesis—avoid isolated resisted elbow flex (0-6 weeks)
Weeks 2-4	Use of strapping tape for secondary AC compression Soft tissue treatments for shoulder & neck	1. Continue with the above 2. Scapula thoracic rhythm through PROM 3. Glenohumeral setting	1. Decrease pain & edema 2. PROM 0°-70° 3. External rotation to 30° 4. Sling use for 4 weeks	1. Restricted combined abduction and external rotation (0-6 weeks) 2. External rotator cuff repair—Avoid restricted external rotation and internal rotation stretch (0-6 weeks) 3. Internal rotator cuff repair (Subscapularis) —Avoid restricted internal rotation and external rotation stretch (0-6 weeks) 4. Slap repair—avoid isolated resisted elbow flex (0-6 weeks) 5. Bicep tenodesis—avoid isolated resisted elbow flex (0-6 weeks)
Weeks 4-6	Continue with soft tissue mobilizations, PROM, and gentle mobilization to increase range of motion	1. Start mid-ROM RT cuff external and internal rotations 2. Active and light resistance exercises (through 75% of ROM as patient's symptoms permit) 3. Without shoulder elevation & avoiding extreme ROM 4. At 6 weeks add supine cane exercise	1. Full shoulder PROM in all planes (flexion, abduction, external & internal rotation 2. AROM full by week 12 3. No overhead lifting	1. Restricted combined abduction and external rotation (0-6 weeks) 2. External rotator cuff repair—Avoid restricted external rotation and internal rotation stretch (0-6 weeks) 3. Internal rotator cuff repair (Subscapularis)—Avoid restricted internal rotation and external 4. Slap repair—avoid isolated resisted elbow flex (0-6 weeks) rotation stretch (0-6 weeks) 5. Bicep tenodesis—avoid isolated resisted elbow flex (0-6 weeks)

(continued)

Table 1. Continued

Time Frame	Manual	Exercise	Goals	Amendments/Comments
Weeks 6-12	Continue with soft tissue mobilizations as needed	1. Gradual loaded exercises into functional range 2. Active stretching into full ROM 3. Scapula thoracic setting and rhythm exercises under load through increased ROM 4. Glenohumeral setting exercises under load through increased ROM	1. Achieve scapula thoracic rhythm under loaded exercises and full ROM 2. Achieve Glenohumeral setting during loaded FROM exercises 3. Achieve full functional ROM 4. Increase function strength through full function ROM	1. Graduated increase in resistance according to contralateral limb
Week 12 & beyond	Continue with soft tissue mobilizations as needed	1. Start a more aggressive RT cuff program as tolerated 2. Start progressive resistance exercises with weights as tolerated 3. Continue to work toward full ROM in all planes 4. Increase intensity of strength and functional training 5. Return to specific sport/work is determined by functional testing specific to the activity	1. Increase strength & endurance 2. Full ROM 3. Initiate slow return to sporting activities	

PROM, passive range of motion; AROM, active range of motion; ROM, range of motion; FROM, full range of motion; AC, acromioclavicular; RT, rotator.

All progressions are approximations and should be used as a guideline only. Progression will be based on individual patient presentation, which is assessed throughout the treatment process.

pilot to clarify concerns but also for the therapist to correct potential mistakes. The treating aeromedical examiner supervises the rehabilitation. In principle, the rehabilitation is not distinctly different to standard treatment, but access to the treating therapist and physician with specific task training with regular progress checks allows the simulation of real-world scenarios. This function-oriented centralized approach with constant communication between pilots and their treating health practitioners allows a focused approach to rehabilitation. The rehabilitation protocol of the MSK Unit after shoulder surgery is summarized in Table 1.

Outcome Measures

Pilots have to undergo an annual medical examination by a certified aeromedical examiner. This license is valid for 12 months and a prerequisite to hold and renew their pilot's/flying license. If a pilot is deemed medically unfit to operate an airplane or fulfill the privileges of their pilot's license, the aeromedical examiner will suspend their medical license by reporting this to the appropriate regulator. The regulator will then suspend the flying license. Reporting and suspension of both medical and flying license is an online process, and the delay between suspension and reinstatement of both licenses is a successive process. Suspension and reinstatement of the medical and pilot's license will occur almost simultaneously with no delay between the 2 processes. Therefore the time period between suspension and reinstatement of the medical license is defined as the time to RTW. Given that the regulator has strict criteria for medical licensing and the fact that air crew is either fit or not to fulfill the privileges of their license with no option of light duties, this period was considered to accurately represent RTW. However, if the time exceeded 30 days, pilots had to undergo simulator and flight checks, including all tasks required for the type of flight and aircraft intended. All outcome measures were obtained by an independent research associate to reduce bias. The time to RTW was defined as the reinstatement of the medical license. This interval was selected because there were requirements for additional simulator checks for some patients, whereas others were able to return to flying duties without additional checks.

Cost savings were calculated on the basis of the median salary of a commercial airline pilot employed by this company and their mean rostered time per week (3.95 days/week). The cost savings were then calculated on the rosterable fraction only.

Statistical analysis

Descriptive statistics were used for outcome measures and return to duty intervals. Normal data

Table 2. Demographics and Outcomes of the Included Pilots

	MSK Unit	External Provider
Number of patients	N = 32	N = 18
Male/Female	M = 32, F = 0	M = 17, F = 1
Age	45.4 ± 9.4	50.3 ± 7.3
Rotator cuff repair	N = 8 (24%)	N = 5 (29%)
Arthroscopic subacromial decompression	N = 15 (45%)	N = 7 (41%)
Bankart repair	N = 7 (21%)	N = 3 (18%)
SLAP repair	N = 2 (5%)	N = 2 (12%)
RTW	85.3 ± 32.8 (95% CI: 72.8-97.9)	117.9 ± 42.5 (95% CI: 102.5-133.34)

CI, confidence interval.

distribution was assessed with the Shapiro-Wilks test, and homogeneity of variance verified with Levene's test. If the data were normally distributed, mean and standard deviation were used. Two-tailed Student *t* tests were used for between-group comparisons. An a priori sample-size calculation was performed and based on the following assumptions: power 80%, alpha 0.05, medium effect size 0.5, earlier between-group RTW 7 days, and enrollment ratio of 2:1. Based on these variables a minimum sample size of 12 patients for group 1 and 24 patients for group 2 were required to achieve adequate power. All analyses were conducted using STATA SE for Windows (version 12.0; StataCorp, College Station, TX).

Results

From January 2017 to June 2021 a total of 103 patients were treated for shoulder conditions. Of those, 54 patients underwent rotator cuff surgery. The MSK unit treated 36 patients (36 males/0 - females, mean age 45.4 ± 9.4), and 18 patients (17 males/1 female, mean age 50.3 ± 7.3) were treated by various external physical therapy providers. Four patients in the MSK group were excluded. One patient had a cardiac stent, the second patient underwent cervical discectomy, the third patient required further surgery for a thumb injury, and the fourth patient ruptured his biceps tendon requiring surgery during the follow-up period (Table 2).

Patients treated by the MSK unit returned to work at a mean of 85.3 ± 32.8 days, and patients treated by external providers returned to work at a mean of 117.9 ± 42.5days (Fig 1). These differences were statistically significant ($P = .02$).

The cost savings for pilots treated by the MSK unit were calculated to be equivalent to 596 rosterable days equating to a total cost saving of $894,353 USD. This equates to a saving of $27,948 USD per pilot. From a rostering point of view, this equates to having 3 additional pilots for operational purposes.

Discussion

The results of this study demonstrated that a multidisciplinary musculoskeletal rehabilitation unit dedicated to pilots reduced the mean time to flying duties by 39% and resulted in significant cost savings for an airline. Because pilots treated by the MSK unit returned to work by a mean of 33 days earlier, the airline was able to save $27,948 USD per pilot.

The majority of patients in both groups underwent subacromial decompression followed by pilots undergoing rotator cuff repair. Previously, Nicholson[8] reported that patients on workers' compensation undergoing arthroscopic acromioplasty was 13.7 weeks compared to 9.1 weeks in a non-workers' compensation group. Similarly, McClelland et al.[7] demonstrated that RTW in manual workers after arthroscopic subacromial decompression was achieved by 3 months in 85%. Jayasekara et al.[11] analyzed RTW after shoulder surgery and showed that 77% of patients returned to work within 6 months of surgery. The type of surgery significantly influenced return to full duty. For example, 38% of patients undergoing rotator cuff repair and 28% of patients after acromioplasty returned to full duties at 6 months.[11]

Obviously, the physical demands of pilots are not comparable to manual workers who can rest intermittently when they experience symptoms, whereas pilots have to be physically fit to perform the tasks required to safely operate an aircraft during routine and emergency situations. In contrast to manual workers, this also prohibits them to use opioid and other central-acting medication.[4,9,10] Although direct comparisons to other professions may not be possible, all pilots returned to work between 9 and 16 weeks with no functional limitations. When comparing the results of this study to that of Nicholson,[8] pilots returned to full duties 1.5 weeks earlier.

One could argue that there might be similarities between athletes and pilots and middle-aged recreational athletes with regard to physical and mental demands, thus allowing better indirect comparisons. Antoni et al.[12] investigated return to recreational sports in patients with a mean age of 57 years after arthroscopic

rotator cuff repair and reported a mean return to sports at 6 months with a return to sports (RTS) rate of 88%. Rossi et al.[13] evaluated RTS in patients with in situ repair of partial-thickness rotator cuff tears and reported similar RTS rates (87%) and RTS time intervals (5.6 months). [13] In a recent meta-analysis Altintas et al.[14] investigated RTS in recreational and competitive athletes who had rotator cuff surgery for both partial- and full-thickness tears of all ages and sports. The authors could not demonstrate any significant differences between competitive and recreational athletes, and age was not associated with the RTS rates (73%). [14]

It appears that pilots have similar RTW time intervals compared to athletes and general workers. However, there were significant differences between pilots undergoing structured rehabilitation in a dedicated MSK unit and external physical therapy providers. The MSK unit includes specialized aeromedical doctors with a background in sports medicine and specialized sports physical therapists working in a unit that allows the simulations of tasks commonly performed in the aircraft such as the strength to pull 50 pounds on the control column in an emergency, the range required to reach overhead switches and oxygen masks, and fine motor control to manipulate switches and flight controls. A possible explanation for these differences could be the prompt assessment, rehabilitation treatment individualized to the demands of the profession as a pilot along, with specialized rehabilitation equipment. In addition, the psychosocial aspect of individualized interventions increases motivation, and confidence may have caused pilots treated by the MSK unit to work harder.[15] With immediate assessment of functional needs and possibilities after surgery and subsequent customization of the individual treatment plan, the effectiveness of the functional rehabilitation process increases and ultimately results in faster recovery.[16] Malviya et al.[17] have shown that professional athletes after hip arthroscopy for femoroacetabular impingement return to sporting activities 2.5 months earlier (40%) when compared to recreational athletes.[17] The authors concluded that professional athletes significantly increased their training time 2.6-fold and believed that training volume contributed to these differences.[17] These effects most likely also played an important role with pilots who were treated in the MSK unit.

Cost-effectiveness, cost-utility, and cost-benefit analysis are a direct result of the increasing cost of health care and become more important when assessing the value of treatment.[18] Quality-adjusted years (QALY) is a generic measure of burden, and 1 QALY is equivalent to 1 year with perfect health.[19] The cost of $50,000 USD per QALY is the current benchmark.[19,20] The cost per QALY for shoulder surgery ranges between $10,000 to $34,000 USD,[21,22] and shoulder surgery is therefore a cost-effective intervention. The cost savings of $24,927 USD per pilot is similar to the cost-utility per QALY, suggesting that rehabilitation in a specialized MSK unit is not only cost-effective but also increases the overall QALY and is value for money.

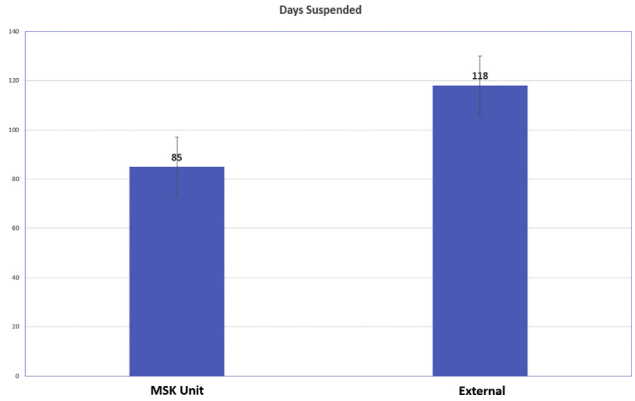

Fig 1. The mean return to work for pilots treated by the MSK unit was 85 days compared to 118 days for pilots treated by external providers.

Limitations

This study has several limitations. Several surgical procedures were included and may have resulted in bias. However, the between-group distribution was very similar, and it is unlikely that these differences influenced outcomes. Unfortunately, subgroup analysis was not possible because of a relatively low sample size and would have resulted in a type II error. The between-group age difference was 5 years, and age-related differences in outcomes could have caused systematic error. Age has been identified as a predictor of outcome.[11,23,24] However, healing rates were only marginally different, and tear size was a more accurate predictor.[25] Tear size was not reported and is a potential limitation in the group of patients who underwent rotator cuff surgery. The study did not control for the type of aircraft. The airline operates only 2 types of aircraft, and it could be argued that joystick controlled airplanes are easier to operate placing less force on the upper extremity. However, the regulations require full control of the upper extremity and clearly state that any musculoskeletal condition that makes someone unable to safely perform the duties or exercise the privileges of their license must not be granted medical clearance.[4] The return to work and reinstatement of the license was based on the regulations of the local regulatory body.[10] Other regulatory authorities may have different functional criteria, and the results of this study cannot therefore not be generalized.

Conclusions

The results of this study of the RTS times of pilots after shoulder surgery range between 85 to 118 days. Rehabilitation in a dedicated MSK reduced the time of return to flying duties by 39%. Pilots treated by the

MSK unit returned to work a mean of 33 days earlier, and the airline was able to save $27,948 USD per pilot.

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