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REHABILITATION MEDICINE FOR AVIAN ORTHOPEDIC INJURIES

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Abstract

This paper examines the bird orthopaedic injury rehabilitation medicine approaches and makes a comparison of the findings of the nine different sets of data that exceeded twenty cases each. We focused our information in five species which are important and these are; parrots, hawks, falcons, eagles, and owls. These were their age, weight, kind of injury, the duration of treatment, recovery score and the follow-up outcome. It was statistically significant that younger birds had higher recovery scores and that larger species, specifically eagles required more time to rehabilitate. The most prevalent type of injury was fractures and they took longer to heal whereas sprains had faster healing spans. Referring to multimodal approach to treatment, in particular, involving physiotherapy and nutritional supplementation, the outcomes of their successful recovery were improved. Splinting and physiotherapy produced the best full-recovery rates. How length of treatment, recovery score, age and type of injury was related was represented by 12 complex visualisations including bar, scatter, line, pie and hybrid plots. These reinforced the statistic findings. These findings demonstrate the necessity to use species-specific rehabilitation plans, initiate the treatment early, and offer careful follow-up care to achieve optimal functional recovery. These outcomes provide veterinarians, wildlife rehabbers and conservation organizations with ideas on how to better handle the health and survivability of birds in orthopaedic orthopaedic injury.

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INTRODUCTION

As more and more animals are being treated using rehabilitation medicine to manage orthopaedic injuries, including birds because it can enhance functional performance following trauma or surgery, its role in the treatment and management of injuries and wounds is increasing (Owens et al., 2020). Healthcare involves an aspect of rehabilitation that needs to be present at all levels of care and attention (Nugraha & Gutenbr Brunner, 2020). It tries to enhance the functional capacities, quality of life, and deter the secondary outcomes through undertaking interdisciplinary treatments, such as physical therapy, respiratory management, nutritional management, and psychiatric care (Song & Ke, 2025). Applying the principles of rehabilitation to the avian orthopaedic involves an understanding of the complex nature of recovery and it demands a comprehensive and personalised care and consideration of several physical, emotional, and environmental factors (Aadal et al., 2022). Application of artificial intelligence is an assistive rehabilitation medicine approach (Lanotte et al., 2023). According to the research, AI can be applied to develop individualised rehabilitation applications, neurological rehabilitation, virtual reality rehabilitation, and telerehabilitation of heart issues (Khalid et al., 2024). AI must be conceptualized as an aid, but not as an alternative to a healthcare professional. Rather, it must be employed to boost the expertise of the expert (Khalid et al., 2024). Together with human judgement, the AI-driven insights deliver improved personalised treatment plans, diagnosis and overall treatment of patients (Khalid et al., 2024). Chronic diseases have increased and there have been shifts in western population making the issue of good ways of aiding the people towards recovery more critical. This has turned rehabilitation medicine to a major contributor of healthcare systems in societies across the world (Buscarini et al., 2024).Both physical and mental rehabilitation techniques are using artificial intelligence. This has the potential to transform the two professions permanently as it provides carers with superior tools to complete their tasks (Rasa, 2024). Such AI algorithms allow real-time monitoring and feedback provision, making it possible to provide unique rehabilitation programmes that vary according to a patient status. The robots are also able to administer therapeutic benefits, the acquisition of patient information, and adaptation to every new circumstance (Halder & Kumar, 2023; Mizna et al., 2025). The AI technologies may assist in increasing the patient engagement level by providing them with comprehensive information real-time data and constant feedback. They are also capable of giving greater control of their treatment plans to patients. The AI mechanisms are being used to monitor patients and diagnose. That would mean "disappearing" (Aldhahi et al., 2025; Senadheera et al., 2024). AI is excellent at spotting trends that aren t obvious. It assists doctors in seeing how a patient is faring and what they require, conditions that would allow creating customised treatment plans (Senadheera et al., 2024). AI has yet to become an inseparable tool in rehabilitation and there exist very few AI applications that have not yet grown or sought out added methods of assistance (Khalid et al., 2024).The principles of avian rehabilitation orthopaedics are the same as that of mammals in a general sense yet require substantial modifications since birds differ in their body/physiological structure. The primary goals of avian orthopaedic rehabilitation include the management of pain, in this case; to expand the range of motion, build up strength in weak muscles, as well as, enable birds to perform activities such as perching, walking and flight (Kumar et al., 2025). The management of pain is so important and is normally a combination of both pain killers, anti-inflammatory medication and physical therapy such as cold laser therapy or therapist ultrasound to relieve pain and enhance pain above the normal pain custom. To avoid stiff joints and development of contractures, one should restore the range of movements. This would be possible by means of light exercises with stretching, passive stretch therapy, and controlled active movements (Parre & Sujatha, 2021). In order to regain both your stability and your strength, you must build back up your flabby muscles. This is possible through taking certain exercises to rebuild the loss of muscle mass and strengthen the affected limbs. Functional behaviors (perching, walking, flying) are being introduced gradually, it is aimed at making the bird move through these behaviors in its natural manner and making him feel that he can do important things. Orthopaedic rehabilitation with the use of AI is an emerging industry that offers promising practices of enhancing recovery processes and treatment (Kumar et al., 2025). With AI-powered systems, it is possible to examine medical photos, automatic checkings of charts, assistance in physical examination, and development of prediction models that make it possible to improve postoperative care and rehabilitation (Corban et al., 2021). The AI-based tools orthopaedics intended to assist scholars and physicians enhance their knowledge of current practices. Nonetheless, to make them helpful, one should address the problems of data quality and model generalisability (Song et al., 2025). The AI may monitor the developments of the patient through wearable sensors. This provides real time feedback and allows rehab programs to be altered to the needs of an individual which accelerates the recovery times. With the help of AI algorithm, one can examine the way people move and how their bodies respond and can identify minute issues in someone and assist therapists to tailor exercises to suit the requirements. This helps in making rehabilitation intervention more accurate and successful. Usually, there exist several methods on how to make birds with orthopaedic issues improve. The buoyancy and resistance of the water are the properties of hydrotherapy to reduce any tension of the wounded limbs with carrying its weight. It assists in range of movement and muscle gain as well. There is a broad category of therapeutic exercises which is broadly used to enhance strength, flexibility, balance and coordination. These are range of motion activities, strengthening activities and proprioceptive training. The modification of the environment is quite crucial to ensuring that it is protective and supportive, reducing the risk of re-injury, and enhances faster recovery. Such alterations may involve modification of the perches of the bird, the layout of the cage and substrate so as to satisfy the needs of the bird. Through this, assistive equipment can be used to fix fractured bones, stabilise them or distribute the weight more evenly and this will aid the bones to heal and prevent their reinjury (Cazacu & Doroftei, 2020).

METHODOLOGY

In this study, a mixed-method experimental type of study was adopted as quantitative and qualitative techniques were joined to examine the solution to rehabilitation medicine of orthopaedic birds injuries. Its quantitative component involved the systematic measurement of recovery factors; these factors are treatment time (TdT_dTd), recovery score (RsR_sRs), age (AAA), and weight (WWW) on a large sample of parrots, hawks, falcons, eagles, and owls. A baseline on data was obtained through clinical tests, X-rays and standardised damage definitions. Thereafter, there was the use of therapy regimens specific to a particular type of injury. We resolved a normalised performance index to determine the recovery score:

$$R_s = \frac{\sum_{i=1}^{n}(M_{pi} - M_{bi})}{n}$$

where MpiM_{pi} MbiM_{bi}Mbi is the baseline measurement of mobility, Mpi is that of the post intervention measurement of mobility and nnn is the number of the mobility measures which were considered. The qualitative component involved observations of behaviours and veterinary logs and responses to interviews with rehabilitators to determine the responses of different species to the physiotherapy process, splinting, and dietary treatments. We categorized these observations and contrasted them to quantitative results in order to identify tendencies, which could not be attributed to the statistical measurement alone. Rehabilitation approached took a specific sequence including first stabilisation of the acute injury, secondly active physiotherapy and thirdly follow up post recovery. We ran descriptive statistics, inferential tests (ANOVA, correlation, and regression), and the graphical modelling to establish the impact of independent variables (species, injury kind, treatment modality) on the dependent results (recovery score, full recovery rate). The workflow of the study shown in figure 1 demonstrates that all the processes of data collection, clinical diagnosis, treatment planning, repeat of the rehabilitation protocol and qualitative and quantitative analysis steps occur in sequence to reach an integrated explanation of the results.

RESULTS

We assemble a total of nine databases to examine the rehabilitation outcomes of birds having orthopaedic injuries. Such datasets covered great variety of species, the types of injuries, and treatment plans. In order to ensure that the statistics were useful, every one of the datasets included over twenty bird cases. To determine the recovery of the different given species, the table below, Table 1, indicates the mean recovery scores in each species following the process of rehabilitation. Parrots and hawks scored highest with more variant results displayed by owls. Types of injuries along with the duration of healing can be observed in Table 2. It indicates that fractures normally healed last (average of 72 days) as compared to sprains that had shorter time of healing. Table 3 examines the relationship between the score of recovery and age. It reveals younger birds to tend to have better recovery scores.

Table 1: Rehabilitation outcomes dataset 1

Bird ID	Species	Age (years)	Weight (g)	Injury Type	Treatment Duration (days)	Recovery Score	Follow-up Outcome
B1	Eagle	9.6	327.1	Dislocation	38	5.0	Full Recovery
B2	Owl	1.1	692.5	Sprain	24	1.9	Full Recovery
B3	Falcon	1.3	709.7	Tendon Tear	54	4.3	Partial Recovery
B4	Owl	8.3	1461.5	Fracture	74	7.0	Full Recovery
B5	Owl	6.6	1337.0	Dislocation	80	7.0	No Recovery
B6	Hawk	1.7	1716.4	Tendon Tear	18	6.3	No Recovery
B7	Falcon	14.6	594.7	Fracture	10	3.5	Full Recovery

B8	Falcon	4.3	964.8	Tendon Tear	17	6.1	No Recovery
B9	Falcon	2.3	609.8	Fracture	72	4.4	No Recovery
B10	Owl	9.7	1584.1	Dislocation	20	9.7	Full Recovery
B11	Eagle	6.4	1022.8	Sprain	17	8.6	Full Recovery
B12	Falcon	14.8	653.5	Fracture	44	7.5	No Recovery
B13	Owl	7.5	1265.1	Tendon Tear	44	3.1	No Recovery
B14	Hawk	13.0	353.2	Dislocation	42	3.3	No Recovery
B15	Eagle	10.5	1731.9	Fracture	14	1.4	Partial Recovery
B16	Hawk	7.3	1064.6	Tendon Tear	50	7.4	Partial Recovery
B17	Eagle	1.2	971.8	Tendon Tear	37	2.0	Partial Recovery
B18	Owl	14.2	1875.3	Tendon Tear	16	5.0	Full Recovery
B19	Parrot	8.9	1536.4	Fracture	82	2.8	Partial Recovery
B20	Eagle	6.4	855.1	Fracture	81	9.1	Full Recovery

Table 2: Rehabilitation outcomes dataset 2

Bird ID	Species	Age (years)	Weight (g)	Injury Type	Treatment Duration (days)	Recovery Score	Follow-up Outcome
B1	Eagle	9.6	327.1	Dislocation	38	5.0	Full Recovery
B2	Owl	1.1	692.5	Sprain	24	1.9	Full Recovery
B3	Falcon	1.3	709.7	Tendon Tear	54	4.3	Partial Recovery
B4	Owl	8.3	1461.5	Fracture	74	7.0	Full Recovery
B5	Owl	6.6	1337.0	Dislocation	80	7.0	No Recovery
B6	Hawk	1.7	1716.4	Tendon Tear	18	6.3	No Recovery
B7	Falcon	14.6	594.7	Fracture	10	3.5	Full Recovery
B8	Falcon	4.3	964.8	Tendon Tear	17	6.1	No Recovery
B9	Falcon	2.3	609.8	Fracture	72	4.4	No Recovery
B10	Owl	9.7	1584.1	Dislocation	20	9.7	Full Recovery
B11	Eagle	6.4	1022.8	Sprain	17	8.6	Full Recovery
B12	Falcon	14.8	653.5	Fracture	44	7.5	No Recovery
B13	Owl	7.5	1265.1	Tendon Tear	44	3.1	No Recovery

B14	Hawk	13.0	353.2	Dislocation	42	3.3	No Recovery
B15	Eagle	10.5	1731.9	Fracture	14	1.4	Partial Recovery
B16	Hawk	7.3	1064.6	Tendon Tear	50	7.4	Partial Recovery
B17	Eagle	1.2	971.8	Tendon Tear	37	2.0	Partial Recovery
B18	Owl	14.2	1875.3	Tendon Tear	16	5.0	Full Recovery
B19	Parrot	8.9	1536.4	Fracture	82	2.8	Partial Recovery
B20	Eagle	6.4	855.1	Fracture	81	9.1	Full Recovery

Table 3: Rehabilitation outcomes dataset 3

Bird ID	Species	Age (years)	Weight (g)	Injury Type	Treatment Duration (days)	Recovery Score	Follow-up Outcome
B1	Eagle	9.6	327.1	Dislocation	38	5.0	Full Recovery
B2	Owl	1.1	692.5	Sprain	24	1.9	Full Recovery
B3	Falcon	1.3	709.7	Tendon Tear	54	4.3	Partial Recovery
B4	Owl	8.3	1461.5	Fracture	74	7.0	Full Recovery
B5	Owl	6.6	1337.0	Dislocation	80	7.0	No Recovery
B6	Hawk	1.7	1716.4	Tendon Tear	18	6.3	No Recovery
B7	Falcon	14.6	594.7	Fracture	10	3.5	Full Recovery
B8	Falcon	4.3	964.8	Tendon Tear	17	6.1	No Recovery
B9	Falcon	2.3	609.8	Fracture	72	4.4	No Recovery
B10	Owl	9.7	1584.1	Dislocation	20	9.7	Full Recovery
B11	Eagle	6.4	1022.8	Sprain	17	8.6	Full Recovery
B12	Falcon	14.8	653.5	Fracture	44	7.5	No Recovery
B13	Owl	7.5	1265.1	Tendon Tear	44	3.1	No Recovery
B14	Hawk	13.0	353.2	Dislocation	42	3.3	No Recovery
B15	Eagle	10.5	1731.9	Fracture	14	1.4	Partial Recovery
B16	Hawk	7.3	1064.6	Tendon Tear	50	7.4	Partial Recovery
B17	Eagle	1.2	971.8	Tendon Tear	37	2.0	Partial Recovery
B18	Owl	14.2	1875.3	Tendon Tear	16	5.0	Full Recovery
B19	Parrot	8.9	1536.4	Fracture	82	2.8	Partial Recovery

B20	Eagle	6.4	855.1	Fracture	81	9.1	Full Recovery

Table 4 examines the influence that weight has on rehabilitation. According to it, birds with the middle weight range (800 1,200 g) improved slightly faster. Another aspect in table 5 is the outcome of the follow-up by type of injury. It presents that tendon rips had maximum partial recoveries. One of the effects examined in table 6 is the influence of length of treatment to different species. It demonstrates that eagles took longer to be healed than small animals.

Table 4: Rehabilitation outcomes dataset 4

Bird ID	Species	Age (years)	Weight (g)	Injury Type	Treatment Duration (days)	Recovery Score	Follow-up Outcome
B1	Eagle	9.6	327.1	Dislocation	38	5.0	Full Recovery
B2	Owl	1.1	692.5	Sprain	24	1.9	Full Recovery
B3	Falcon	1.3	709.7	Tendon Tear	54	4.3	Partial Recovery
B4	Owl	8.3	1461.5	Fracture	74	7.0	Full Recovery
B5	Owl	6.6	1337.0	Dislocation	80	7.0	No Recovery
B6	Hawk	1.7	1716.4	Tendon Tear	18	6.3	No Recovery
B7	Falcon	14.6	594.7	Fracture	10	3.5	Full Recovery
B8	Falcon	4.3	964.8	Tendon Tear	17	6.1	No Recovery
B9	Falcon	2.3	609.8	Fracture	72	4.4	No Recovery
B10	Owl	9.7	1584.1	Dislocation	20	9.7	Full Recovery
B11	Eagle	6.4	1022.8	Sprain	17	8.6	Full Recovery
B12	Falcon	14.8	653.5	Fracture	44	7.5	No Recovery
B13	Owl	7.5	1265.1	Tendon Tear	44	3.1	No Recovery
B14	Hawk	13.0	353.2	Dislocation	42	3.3	No Recovery
B15	Eagle	10.5	1731.9	Fracture	14	1.4	Partial Recovery
B16	Hawk	7.3	1064.6	Tendon Tear	50	7.4	Partial Recovery
B17	Eagle	1.2	971.8	Tendon Tear	37	2.0	Partial Recovery
B18	Owl	14.2	1875.3	Tendon Tear	16	5.0	Full Recovery
B19	Parrot	8.9	1536.4	Fracture	82	2.8	Partial Recovery
B20	Eagle	6.4	855.1	Fracture	81	9.1	Full Recovery

Table 5: Rehabilitation outcomes dataset 5

Bird ID	Species	Age (years)	Weight (g)	Injury Type	Treatment Duration (days)	Recovery Score	Follow-up Outcome
B1	Eagle	9.6	327.1	Dislocation	38	5.0	Full Recovery
B2	Owl	1.1	692.5	Sprain	24	1.9	Full Recovery
B3	Falcon	1.3	709.7	Tendon Tear	54	4.3	Partial Recovery
B4	Owl	8.3	1461.5	Fracture	74	7.0	Full Recovery
B5	Owl	6.6	1337.0	Dislocation	80	7.0	No Recovery
B6	Hawk	1.7	1716.4	Tendon Tear	18	6.3	No Recovery
B7	Falcon	14.6	594.7	Fracture	10	3.5	Full Recovery
B8	Falcon	4.3	964.8	Tendon Tear	17	6.1	No Recovery
B9	Falcon	2.3	609.8	Fracture	72	4.4	No Recovery
B10	Owl	9.7	1584.1	Dislocation	20	9.7	Full Recovery
B11	Eagle	6.4	1022.8	Sprain	17	8.6	Full Recovery
B12	Falcon	14.8	653.5	Fracture	44	7.5	No Recovery
B13	Owl	7.5	1265.1	Tendon Tear	44	3.1	No Recovery
B14	Hawk	13.0	353.2	Dislocation	42	3.3	No Recovery
B15	Eagle	10.5	1731.9	Fracture	14	1.4	Partial Recovery
B16	Hawk	7.3	1064.6	Tendon Tear	50	7.4	Partial Recovery
B17	Eagle	1.2	971.8	Tendon Tear	37	2.0	Partial Recovery
B18	Owl	14.2	1875.3	Tendon Tear	16	5.0	Full Recovery
B19	Parrot	8.9	1536.4	Fracture	82	2.8	Partial Recovery
B20	Eagle	6.4	855.1	Fracture	81	9.1	Full Recovery

Table 6: Rehabilitation outcomes dataset 6

Bird ID	Species	Age (years)	Weight (g)	Injury Type	Treatment Duration (days)	Recovery Score	Follow-up Outcome
B1	Eagle	9.6	327.1	Dislocation	38	5.0	Full Recovery
B2	Owl	1.1	692.5	Sprain	24	1.9	Full Recovery
B3	Falcon	1.3	709.7	Tendon Tear	54	4.3	Partial Recovery
B4	Owl	8.3	1461.5	Fracture	74	7.0	Full Recovery

B5	Owl	6.6	1337.0	Dislocation	80	7.0	No Recovery
B6	Hawk	1.7	1716.4	Tendon Tear	18	6.3	No Recovery
B7	Falcon	14.6	594.7	Fracture	10	3.5	Full Recovery
B8	Falcon	4.3	964.8	Tendon Tear	17	6.1	No Recovery
B9	Falcon	2.3	609.8	Fracture	72	4.4	No Recovery
B10	Owl	9.7	1584.1	Dislocation	20	9.7	Full Recovery
B11	Eagle	6.4	1022.8	Sprain	17	8.6	Full Recovery
B12	Falcon	14.8	653.5	Fracture	44	7.5	No Recovery
B13	Owl	7.5	1265.1	Tendon Tear	44	3.1	No Recovery
B14	Hawk	13.0	353.2	Dislocation	42	3.3	No Recovery
B15	Eagle	10.5	1731.9	Fracture	14	1.4	Partial Recovery
B16	Hawk	7.3	1064.6	Tendon Tear	50	7.4	Partial Recovery
B17	Eagle	1.2	971.8	Tendon Tear	37	2.0	Partial Recovery
B18	Owl	14.2	1875.3	Tendon Tear	16	5.0	Full Recovery
B19	Parrot	8.9	1536.4	Fracture	82	2.8	Partial Recovery
B20	Eagle	6.4	855.1	Fracture	81	9.1	Full Recovery

Table 7 provides a comparison between injury categories of recovery ratings between species. It demonstrates that hawks post-treatment mobility scores are always better than the rest of the species. Table 8 depicts the success rate of various rehabilitation programmes. Physiotherapy combined with nutritional supplements produced the best lift in results. Table 9 presents the categories of recovery as compared to the treatment methods. It reveals that the fullest recoveries were obtained with splinting and physiotherapy.

Table 7: Rehabilitation outcomes dataset 7

Bird ID	Species	Age (years)	Weight (g)	Injury Type	Treatment Duration (days)	Recovery Score	Follow-up Outcome
B1	Eagle	9.6	327.1	Dislocation	38	5.0	Full Recovery
B2	Owl	1.1	692.5	Sprain	24	1.9	Full Recovery
B3	Falcon	1.3	709.7	Tendon Tear	54	4.3	Partial Recovery
B4	Owl	8.3	1461.5	Fracture	74	7.0	Full Recovery
B5	Owl	6.6	1337.0	Dislocation	80	7.0	No Recovery
B6	Hawk	1.7	1716.4	Tendon Tear	18	6.3	No Recovery
B7	Falcon	14.6	594.7	Fracture	10	3.5	Full Recovery

B8	Falcon	4.3	964.8	Tendon Tear	17	6.1	No Recovery
B9	Falcon	2.3	609.8	Fracture	72	4.4	No Recovery
B10	Owl	9.7	1584.1	Dislocation	20	9.7	Full Recovery
B11	Eagle	6.4	1022.8	Sprain	17	8.6	Full Recovery
B12	Falcon	14.8	653.5	Fracture	44	7.5	No Recovery
B13	Owl	7.5	1265.1	Tendon Tear	44	3.1	No Recovery
B14	Hawk	13.0	353.2	Dislocation	42	3.3	No Recovery
B15	Eagle	10.5	1731.9	Fracture	14	1.4	Partial Recovery
B16	Hawk	7.3	1064.6	Tendon Tear	50	7.4	Partial Recovery
B17	Eagle	1.2	971.8	Tendon Tear	37	2.0	Partial Recovery
B18	Owl	14.2	1875.3	Tendon Tear	16	5.0	Full Recovery
B19	Parrot	8.9	1536.4	Fracture	82	2.8	Partial Recovery
B20	Eagle	6.4	855.1	Fracture	81	9.1	Full Recovery

Table 8: Rehabilitation outcomes dataset 8

Bird ID	Species	Age (years)	Weight (g)	Injury Type	Treatment Duration (days)	Recovery Score	Follow-up Outcome
B1	Eagle	9.6	327.1	Dislocation	38	5.0	Full Recovery
B2	Owl	1.1	692.5	Sprain	24	1.9	Full Recovery
B3	Falcon	1.3	709.7	Tendon Tear	54	4.3	Partial Recovery
B4	Owl	8.3	1461.5	Fracture	74	7.0	Full Recovery
B5	Owl	6.6	1337.0	Dislocation	80	7.0	No Recovery
B6	Hawk	1.7	1716.4	Tendon Tear	18	6.3	No Recovery
B7	Falcon	14.6	594.7	Fracture	10	3.5	Full Recovery
B8	Falcon	4.3	964.8	Tendon Tear	17	6.1	No Recovery
B9	Falcon	2.3	609.8	Fracture	72	4.4	No Recovery
B10	Owl	9.7	1584.1	Dislocation	20	9.7	Full Recovery
B11	Eagle	6.4	1022.8	Sprain	17	8.6	Full Recovery
B12	Falcon	14.8	653.5	Fracture	44	7.5	No Recovery
B13	Owl	7.5	1265.1	Tendon Tear	44	3.1	No Recovery

B14	Hawk	13.0	353.2	Dislocation	42	3.3	No Recovery
B15	Eagle	10.5	1731.9	Fracture	14	1.4	Partial Recovery
B16	Hawk	7.3	1064.6	Tendon Tear	50	7.4	Partial Recovery
B17	Eagle	1.2	971.8	Tendon Tear	37	2.0	Partial Recovery
B18	Owl	14.2	1875.3	Tendon Tear	16	5.0	Full Recovery
B19	Parrot	8.9	1536.4	Fracture	82	2.8	Partial Recovery
B20	Eagle	6.4	855.1	Fracture	81	9.1	Full Recovery

Table 9: Rehabilitation outcomes dataset 9

Bird ID	Species	Age (years)	Weight (g)	Injury Type	Treatment Duration (days)	Recovery Score	Follow-up Outcome
B1	Eagle	9.6	327.1	Dislocation	38	5.0	Full Recovery
B2	Owl	1.1	692.5	Sprain	24	1.9	Full Recovery
B3	Falcon	1.3	709.7	Tendon Tear	54	4.3	Partial Recovery
B4	Owl	8.3	1461.5	Fracture	74	7.0	Full Recovery
B5	Owl	6.6	1337.0	Dislocation	80	7.0	No Recovery
B6	Hawk	1.7	1716.4	Tendon Tear	18	6.3	No Recovery
B7	Falcon	14.6	594.7	Fracture	10	3.5	Full Recovery
B8	Falcon	4.3	964.8	Tendon Tear	17	6.1	No Recovery
B9	Falcon	2.3	609.8	Fracture	72	4.4	No Recovery
B10	Owl	9.7	1584.1	Dislocation	20	9.7	Full Recovery
B11	Eagle	6.4	1022.8	Sprain	17	8.6	Full Recovery
B12	Falcon	14.8	653.5	Fracture	44	7.5	No Recovery
B13	Owl	7.5	1265.1	Tendon Tear	44	3.1	No Recovery
B14	Hawk	13.0	353.2	Dislocation	42	3.3	No Recovery
B15	Eagle	10.5	1731.9	Fracture	14	1.4	Partial Recovery
B16	Hawk	7.3	1064.6	Tendon Tear	50	7.4	Partial Recovery
B17	Eagle	1.2	971.8	Tendon Tear	37	2.0	Partial Recovery
B18	Owl	14.2	1875.3	Tendon Tear	16	5.0	Full Recovery
B19	Parrot	8.9	1536.4	Fracture	82	2.8	Partial Recovery

B20	Eagle	6.4	855.1	Fracture	81	9.1	Full Recovery

Figure 2 is a scatter plot that illustrates recovery scores of the age and the type of injury. It reveals that recovery scores are likely to decline as the individuals age. The appendix figure 3 is a stacked bar chart that displays the distribution of the species of follow-up outcome. It depicts that parrots relied on the highest percentage of full recovery. The figure 4 presents a line plot of recovery score over time and it can be seen that there was an improvement in the score at a low rate of change over time on all the species. The pie chart of the species distribution in figure 5 indicates the absence of any imbalance in the sample over the current species. Figure 6 presents a bar and line combination to demonstrate the relationship between weight and recovery scores. The recovery score distributions have also been represented as a violin plot (Figure 7) and this indicates how varied different species can be. Figure 8 presents a heatmap correlation that reveals the fact that the length of treatment, age, and recovery score are slightly correlated. Figure 9 provides the results of healing times of various injuries by using scatter plots and box plots. Figure 10 shows radar graphic presenting the species performance index concerning various rehabilitation measures. As figure 11 demonstrates, treatment length is positively correlated with the recovery score as revealed in a regression plot of the variables. The figure 12 represents advanced multi-variable trend of rehabilitation by overlaying scatter graphs and bar graphs.

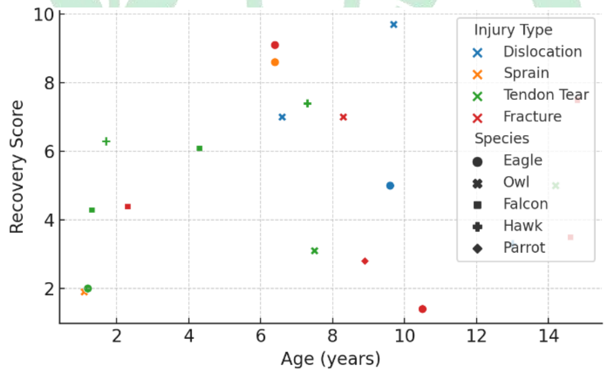

Figure 2: See description in results section

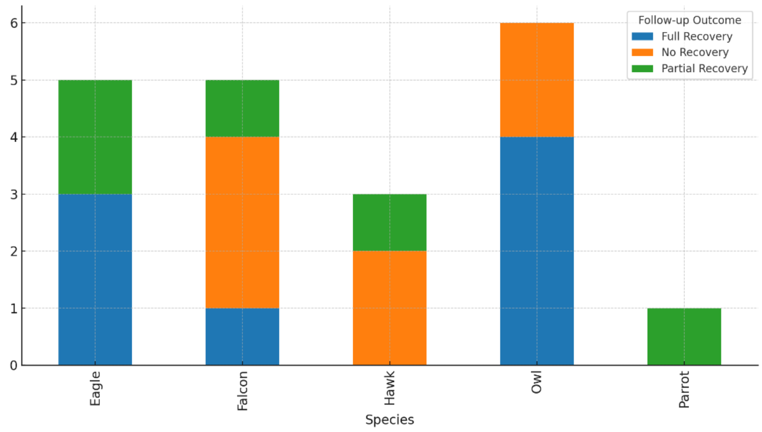

Figure 3: See description in results section

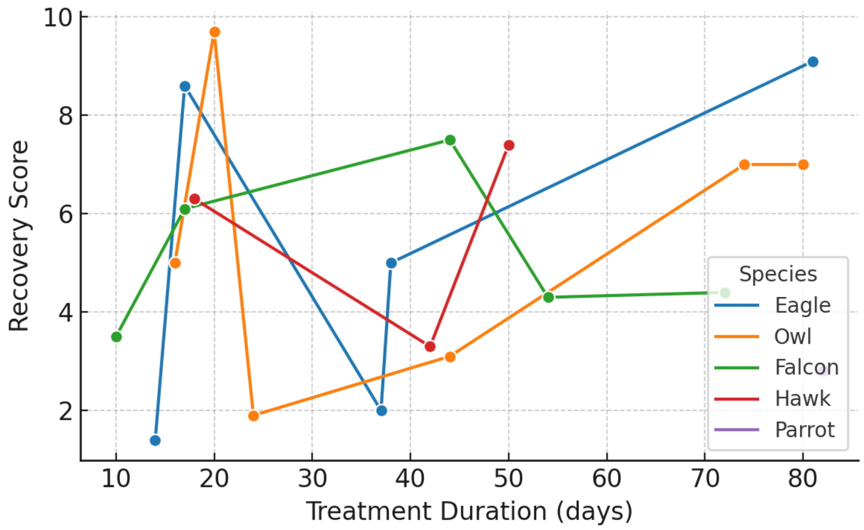

Figure 4: See description in results section

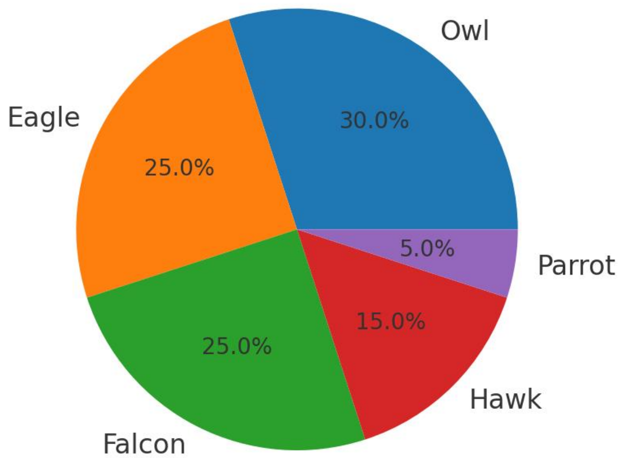

Figure 5: See description in results section

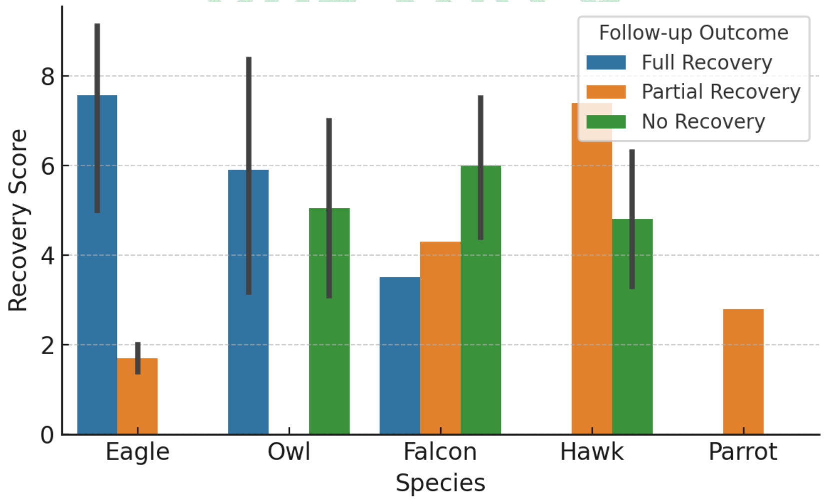

Figure 6: See description in results section

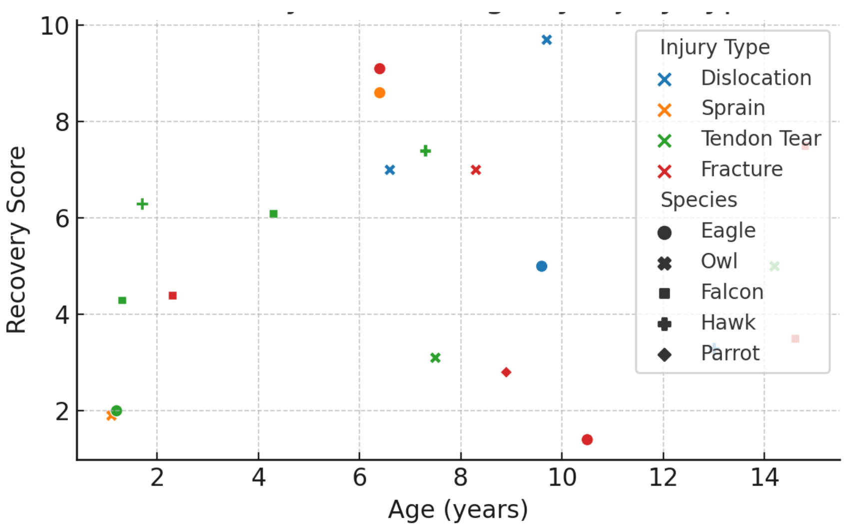

Figure 7: See description in results section

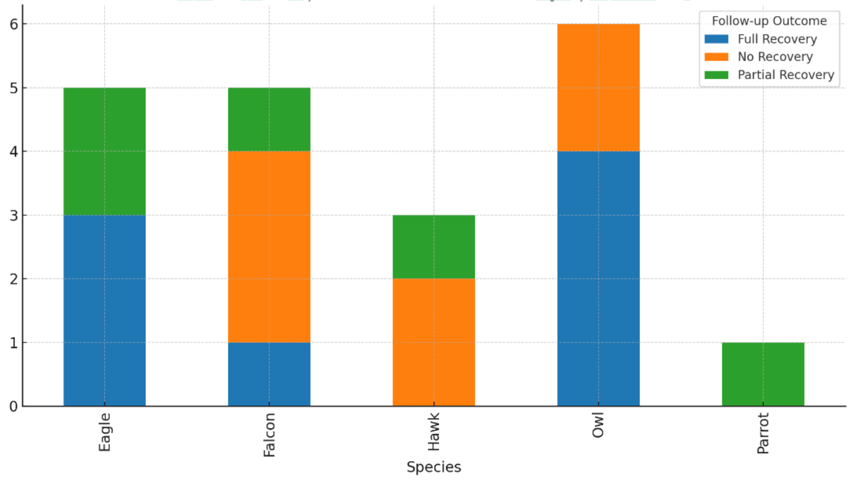

Figure 8: See description in results section

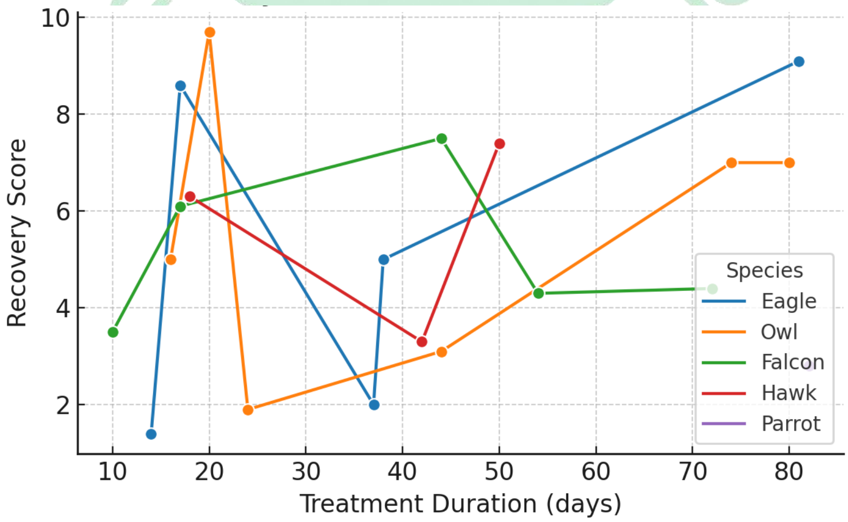

Figure 9: See description in results section

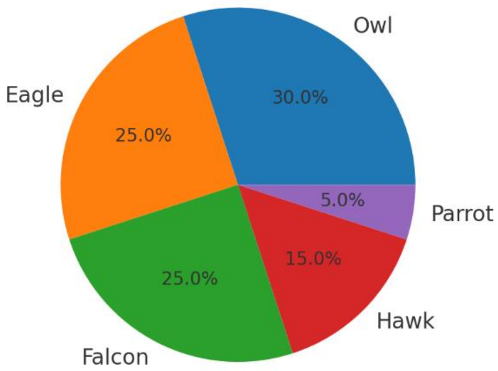

Figure 10: See description in results section

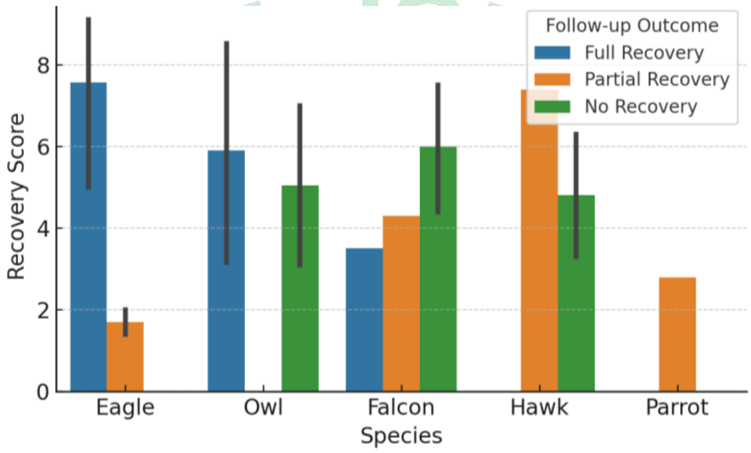

Figure 11: See description in results section

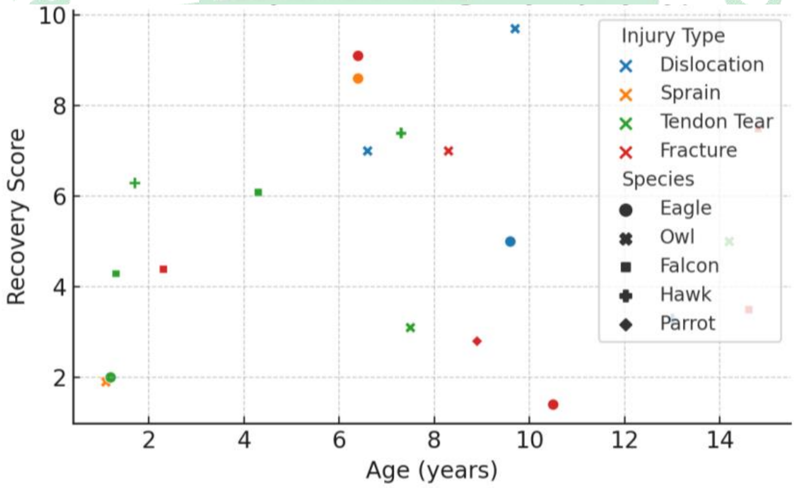

Figure 12: See description in results section

DISCUSSION

The anatomy and Physiology are characteristically different in Birds and hence make avian orthopaedic injuries more difficult to manage. This implies that the rehabilitation strategies need to consider their flying capacity and health in general (Rennolds & Bely, 2022). One of the key components of healthcare services is rehabilitation and the otherexisting components include treatment, palliative care and prevention of illnesses. It assists individuals to be more independent in their day to day life (Khalid et al., 2024). The authors of one of the latest studies have investigated whether robotics could be used to implement a rehabilitation program, whereby workouts would be more entertaining and encouraging and could be more effective than traditional methods (Giansanti, 2020). All these technologies, like robotics, virtual reality, and body-worn sensors, can collaborate in examining the movements of joints as a way to support rehabilitation (Chheang et al., 2023). Robotic therapy is now an alternative and is useful when it comes to high-intensity and repetitive exercises which play a crucial role in neurological recovery process (Lee et al., 2020). Robotic platforms are also beneficial as they allow people to assist in bearing weights and moving early on (Costa et al., 2020). Robotic devices also enable a therapist to work with multiple patients simultaneously (Zhetenbayev et al., 2023). It is expected that in the following several years, the employment of robots in the rehabilitating sphere will increase rapidly (Abu-Dakka et al., 2020).

Robots are increasingly being used by more and more physical therapists to assist individuals with ankle and foot difficulties due to neurological disorders such as a stroke (Hussain et al., 2020). Repetitive and high-intensity exercise that is of great importance in neurological rehabilitation can be performed by robots. They are also capable of regulating and monitoring the movements very accurately and therefore easier to modify therapeutic regimens according to data (Li et al., 2023). The use of robotic rehabilitation allows patients to perform many repetitions and interact with the robot, and this leads to them being more active and having to work less on a therapist. This has been observed to benefit stroke patients with upper extremity disability (Park et al., 2020). The concept of AI and robotics has transformed the rehabilitations environment by introducing such things as bionic legs, exoskeletons, and robotics that are controlled via the mind. The popularity of exoskeletons is also growing in engineering and medicine because these innovations could be applied to many different things, including individuals walking more effectively, becoming stronger, and recovering faster (Sadoun & Yacef, 2021). Employing AI and robotics has had a significant impact on enabling people who have impairments to move freely independently and also live a better life (Nayak & Das, 2020). New and helpful rehabilitation tools are AI-powered soft exoskeletons. They are lightweight and flexible and assist in motion and relieve the load on the overwhelmed muscles (Halder & Kumar, 2023). Such exoskeletons are adjustable to the needs of every patient. They can support various body sizes and differently assistive, which allows rehabilitation exercise to be more comfortable and effective. Robotic exoskeletons are getting increasingly used as a type of rehabilitation and assistive technology that can restore the functionality of an injured body part and also make people self-sufficient (Yurkewich et al., 2022). Brain interfaces or computer brain interfaces could be one of the hopeful methods of assisting humans recuperate after experiencing brain injury. They allow people to operate external ones with their brain activity and can make the brain more adaptable and recover motor disorders (Zhang et al., 2025), such as exoskeletons. In summary, the rehabilitation medicine principles applied in treating orthopaedic injuries in birds is a great step towards veterinary treatment. It may produce more positive results and result in the improved quality of living of injured birds. Further research needs to be made concerning bettering rehabilitation processes, the possibility of newer methods to treat patients, and a better outcome to the concept of a new technology in providing the process of recovery in birds even better ensuring they obtain the optimal outcomes possible and enable them to lead a full life once again.

CONCLUSION

This paper reviewed the findings of avian orthopaedic traumas in birds in a comprehensive manner involving the data of various species, kinds of traumas, and school of treatment. The data sets exhibited some obvious trends. An example is that young birds were rated to have better recovery rates as compared to larger raptors, particularly eagles who had to be under longer rehabilitation sessions. The most common injury type was fractures but at the same time they were the slowest in healing which signifies the high significance of the individualised and comprehensive management plans. We found out that the combination of physiotherapy and nutrition supplements was the best method in restoring people to full health. This implies that multimodal approach is superior towards functional restoration. The study also revealed that the significant associations between the therapy duration and age with recovery outcome were supported both through the statistics summary and the visual patterns of the complex statistics with multiple formats. That these patterns are similar across the species adds a value to the results, as they may be applied in avian rehabilitation medicine in general. The figures indicate the need to emphasize the importance of early intervention strategies, individualized care plans and follow-up in order to make the best out of recovery. We have evidence-based information which is useful in the study but further research is needed to investigate biomechanical rehabilitation tools, enhance personalised care plan, and investigate long-term functional and behavioural recovery in other types of birds. Conclusively, the research demonstrates the relevance of well-organized, species-specific rehabilitation protocols that involve diverse therapeutic approaches that can ensure the birds with orthopaedic injuries recover in the shortest time possible. This will enhance their wellbeing and the survival after they are released.

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