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Comparison of the Effects of Eight Weeks of Aquatic Therapy with and without Pilates on Proprioception in Elderly Women with a History of Hip Surgery

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Abstract

Background and Objective: Hip fractures in elderly women pose a significant health concern due to the increased prevalence of osteoporosis and the associated risks of falls. Understanding the nature, causes, treatment options, and outcomes of these fractures is essential for improving patient care and minimizing complications. This study aimed to compare the effects of two exercise methods—aquatic therapy alone and a combination of aquatic therapy and Pilates—over 8 weeks on the proprioception of the hip joint in elderly women with a history of hip surgery.

Materials and Methods: This was a randomized controlled clinical trial with a pre-test and post-test design. Thirty-six women with a history of hip surgery participated in the study. The participants were randomly assigned to three groups: the aquatic exercise group (n=12), the combined exercise group (aquatic therapy plus Pilates) (n=12), and the control group (n=12). The intervention groups performed the respective exercises in addition to their daily activities, while the control group only engaged in their regular activities throughout the study period. Proprioception was assessed using a goniometer before and after the intervention. Data were analyzed using repeated-measures analysis of variance (ANOVA) in SPSS version 21.

Results: The findings revealed significant differences in the proprioception of the hip joint between the intervention groups and the control group, as well as between the two intervention groups. Specifically, the combined exercise group (aquatic therapy and Pilates) showed a greater effect and higher effect size on improving joint proprioception compared to the aquatic therapy group (P=0.001).

Conclusion: It is recommended that coaches, occupational therapists, corrective exercicses specialists, and sports physiotherapists incorporate the benefits of a combined aquatic therapy and Pilates program into their rehabilitation plans, considering the specific needs and abilities of this population.

Key words: *Aquatic exercises, Pilates,a history of hip joint surgery, proprioception.*

Introduction

Hip fractures in elderly women represent a major health concern, especially due to the increasing prevalence of osteoporosis and the associated risks of falling. Understanding the nature causes,

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treatment options and outcomes of these fractures is essential for improving patient care and minimizing complications (García et al., 2020). Although hip fractures are relatively uncommon, they are becoming an increasingly significant issue within the elderly population, particularly among women. The incidence of these fractures rises with age, primarily due to factors like decreased bone density and the higher risk of falling. Approximately 3% of all fractures in adults are hip fractures, with a higher incidence in older individuals due to low-energy impacts such as falls from a standing height (Picon et al., 2021). The psychological and social impact of hip fractures is profound, with many patients experiencing heightened anxiety and social isolation following the injury (Taylor et al., 2024). A common outcome is the transition from independent living to potential home nursing care. The proportion of people requiring organized care doubles after a hip fracture. Furthermore, the psychological effects may result in long-term emotional distress, including depression and reduced participation in social activities. This issue is worsened by the social stigma associated with aging and disability, which can further alienate those affected (Taylor et al., 2024). The long-term consequences of hip fractures are significant. Many individuals who lived independently before their fracture may become reliant on caregivers or institutional support afterward. Loss of muscle mass and strength during recovery can increase the risk of subsequent falls, leading to a cycle of declining physical health and independence (Shiga et al., 2008).

Recent studies have examined the impact of various exercise methods on the health and physical function of elderly women. Research has shown that aquatic exercises can help improve muscle strength and increase the range of motion. For example, one study found that aquatic exercises reduced lower back pain and improved physical performance in elderly women (Babaei et al., 2021). Additionally, Pilates exercises, which focus on strengthening core muscles and improving balance, have a positive effect on range of motion and muscle strength (Jolayi et al., 2017). Pilates involves a series of low or moderate-intensity movements designed to stretch, strengthen, and balance the body (Mousavi et al., 2022). Pilates exercises include multi-axis trunk and limb movements that start with stabilizing the core and continue through a controlled range of motion (Widan et al., 2005). The practice also promotes awareness and improvement of body posture. The discipline includes 500 stretching and strengthening movements, divided into two categories: mat exercises, typically done seated and using equipment such as balls, resistance bands, and others, and machine exercises, which require resistance through stretching or jumping (Mai, 2021; Kokiya, 2024; Moja, 2012). Another unique

feature of Pilates is that it engages the entire body, contracting both the largest and smallest muscles. The movements in Pilates differ from traditional exercises (Kim, 2013). Pilates emphasizes the importance of practical motivation for improving motor learning through rigorous practice and repetition of proper movements to achieve training standards, leading to better motor performance and reduced injury risk (Rodriguez et al., 2002).

Aquatic exercises are beneficial due to the buoyancy of water, which reduces joint pressure and helps increase the range of motion (Babaei et al., 2021). Research has demonstrated that these exercises can alleviate chronic pain and improve quality of life. Pilates, with its focus on core muscle strengthening, can enhance overall body strength and prevent injuries (Jolayi et al., 2017). These exercises can also improve balance, which is particularly important for elderly women. Overall, both exercise methods can positively impact the range of motion, strength, and hip joint function in elderly women. However, the choice between these two methods may depend on individual conditions, previous activity levels, and personal preferences. Further research is required to determine the best exercise protocols for this age group.

Aquatic therapy can be an effective intervention for elderly women with a history of hip surgery, particularly in enhancing balance, reducing pain, and improving overall function. One study found that an aquatic therapy program significantly improved balance in elderly women, reducing the risk of falls, which is particularly important given that falls are a significant health concern in this population (Moureira et al., 2020). Aquatic therapy has been shown to reduce pain and improve functional abilities in elderly women with conditions like knee osteoarthritis. In a controlled trial, participants reported significant reductions in pain levels and improvements in function after completing an aquatic therapy regimen (Fisher et al., 2006).

Mousavi Sadati et al. (2022) compared the effects of selected Pilates exercises, resistance band exercises, and weight training on the strength and flexibility of elderly women. All three groups showed significant progress, but no significant differences were found between the groups, as none of the methods were superior to the others. Therefore, performing Pilates, weight training, and resistance band exercises, depending on the availability of equipment and facilities for elderly individuals, is beneficial. This exercise regimen can reduce negative physical outcomes and associated healthcare costs, slow the aging process, and improve the daily activities of elderly individuals. Research suggests that both aquatic exercises and Pilates can improve flexibility, strength, and overall functional performance in the elderly. For example, aquatic exercises have been shown to provide therapeutic benefits such as reducing joint pain and improving mobility due to the buoyancy of water, which decreases joint stress while providing resistance to strengthen muscles (Bartels et al.,

2016).

The need to compare these two exercise methods arises from the importance of identifying the most effective rehabilitation strategy to improve hip joint function in this specific population. While both methods have demonstrated positive outcomes in enhancing functional abilities and reducing pain, understanding their relative effectiveness enables healthcare providers to more effectively tailor rehabilitation programs to meet individual needs. Previous studies indicate that both hydrotherapy (aquatic exercises) and land-based exercises yield similar improvements in functional tests among elderly individuals with knee osteoarthritis. This suggests a potential equivalence in effectiveness, which may also apply to hip rehabilitation (Etesami et al., 2022).

Water-based training offers a distinctive environment that is ideal for rehabilitation. The properties of water enable low-impact exercises, making them especially beneficial for elderly individuals with joint problems. Research has shown that water exercises can significantly alleviate pain, improve joint function, and enhance overall physical health in the elderly. Furthermore, the warm water used in many aquatic programs can help reduce stiffness and promote muscle relaxation, making it an excellent option for post-surgery rehabilitation (Bartels et al., 2016). Conducting a study that compares these two methods not only adds to existing knowledge but also informs clinical practices regarding rehabilitation strategies for elderly women after hip surgery. Therefore, the goal of this study is to compare the effects of eight weeks of aquatic therapy, with and without Pilates, on proprioception of hip joint in elderly women with a history of hip surgery.

Research Methodology

This study utilized a randomized clinical trial design with pre-test and post-test measurements. The study population included elderly women aged 60 to 75 years who had a history of hip surgery in Tehran. Convenience sampling was employed, and the sample size was calculated using G Power software (effect size 0.15, test power 0.8, and significance level 0.05), resulting in 36 participants. The sample was recruited from corrective exercise centers in Tehran, and participants were randomly assigned to one of three groups: water exercise, water exercise with Pilates, and a control group. The intervention groups participated in eight weeks of aquatic exercises combined with Pilates, while the control group maintained their usual daily activities without engaging in any structured exercise program.

Research Instruments

Hip joint proprioception was assessed using a goniometer. The hip joint was tested at a 60-degree flexion angle. For the active restoration test, the joint was positioned at a zero-degree angle, and participants were instructed to return the joint to the original position with their eyes closed. The angular discrepancy was measured, and the test was repeated three times. The average of the three recorded angles was used as the index for joint

proprioception. This test was performed both before and after the treatment protocol, with the difference between the two stages representing the change in proprioception. A smaller difference indicates better joint proprioception (Hou, 2010).

Aquatic Exercise Protocol

The exercise sessions were held three times per week, with each session lasting one hour. The sessions took place in a pool, maintaining a water temperature of 27–28°C. The intensity of the exercises was set at 55% of the participant's maximum heart rate, which was calculated as 220 minus the participant's age. Each exercise was performed in three sets of 15 repetitions per set. During the first two weeks, exercises were performed with water resistance, and from the third week onward, the resistance was gradually increased by 5% each week by adjusting the weight attached to the target body part (Table 1).

Table 1: Hydrotherapy Exercises

No.	Exercise Title	Exercise Description	Objective
1	Hamstring Stretch	Place your heel on the pool step and grab the step with your hands. Keeping your spine straight, bend forward from the hip and bring your torso forward.	Creating stretch and flexibility in the hamstring muscles.
2	Gluteus Maximus Stretch	Lift one knee and with both hands, hold under the knee and pull it as close as possible toward your chest.	Creating stretch in the gluteal and hamstring muscles.
3	Back Muscle Stretch	Hang vertically inside a floating tube. Bring both knees toward your chest and hold under your knees with your hands.	Creating stretch in the gluteal muscles.
4	Pelvic Tilt	Stand with your back to the pool wall. Contract your abdominal and gluteal muscles, trying to press the arch of your back against the wall so that your pelvis moves upward.	Creating contraction in the abdominal muscles and reducing the curvature of the lower back.
5	Pelvic Contraction	Stand with your back to the pool wall and hold the edge of the pool with both hands. Without lifting your back from the wall, contract your abdominal muscles and gently lift your legs from the pool floor so your knees are bent at 90 degrees.	Creating stretch in the gluteal muscles and strengthening the abdominal and quadriceps muscles.
6	Trunk Flexion with Elastic Band	Secure an elastic band to the pool ladder and stand facing the pool wall. Grab the band with your hands while your arms are bent. Contract your abdominal muscles to flex your spine and pull the band.	Creating contraction in the abdominal muscles.
7	Knee to Chest	Lie on your back inside a floating tube. While a smaller tube is around your ankles, gently bend your thighs and knees, bringing your knees toward your chest.	Creating contraction in the abdominal and quadriceps

		Slowly bend your spine.	muscles.
8	Maintain Pelvic Tilt in Standing Position	Stand upright holding a ball in front of your chest. Contract your abdominal and gluteal muscles to flatten your lower back. Now, gently bend your torso slightly forward.	Creating contraction in the gluteal and abdominal muscles and reducing the curvature of the lower back.
9	Leg Abduction in the Sitting Position	Float in the water so that your hips are bent at a 90-degree angle, your knees are straight, and your arms are positioned away from your body. Move your legs apart from the hip joint and then bring them back together.	Strengthening the abdominal muscles and hip adductors.

Pilates exercises

The Pilates program spanned eight weeks, consisting of three sessions per week, each lasting approximately 50 to 60 minutes. Each session included a 10–15 minute Pilates-specific warm-up, followed by 30 minutes of core Pilates exercises. These exercises addressed various elements, such as posture alignment, relaxation, stretching, balance, respiratory endurance, and strength training, and concluded with a 15-minute Pilates-specific cool-down. The exercises were organized in progressive stages, beginning at the introductory level and increasing in difficulty as participants advanced. For this study, the exercises were carefully selected and adapted by the researcher from multiple reputable sources to align with the participants' physical capabilities. The final program was reviewed and approved by academic experts and physiotherapy specialists, and the sessions were conducted under the supervision of a licensed physiotherapist. The protocol comprised six key components: warm-up, abdominal muscle strengthening, spinal control and mobilization, lateral and shoulder stability, back strengthening, pelvic stability, and thigh endurance. Before initiating the exercise program, participants were instructed on proper breathing techniques for inhalation and exhalation. The number of repetitions for each exercise ranged from 6 to 10, depending on individual capability, with gradual progression from basic to more advanced levels (Rozik et al., 2020).

The data were analyzed using a repeated measures analysis of variance (ANOVA). A significance level of 95% was set for the entire study, with $\alpha \geq 0.05$. All statistical procedures, including descriptive and inferential statistics, were conducted using SPSS software.

Findings

The demographic characteristics of the study participants are presented in Table 2. A one-way ANOVA was conducted to compare the demographic variables across the three groups. The analysis revealed no significant differences in any of the measured variables ($p \geq 0.05$), indicating that the groups were homogeneous in terms of

demographic characteristics.

Table 2: General Characteristics of Participants in the Two Study Groups (Mean and Standard Deviation)

Variable	Water Exercise Group (Mean ± Standard Deviation)	Combined Exercise Group (Water and Pilates) (Mean ± Standard Deviation)	Control Group (Mean ± Standard Deviation)	P
Age (years)	57.00 ± 6.72	58.30 ± 5.52	58.50 ± 7.94	0.78
Height (cm)	166.80 ± 5.25	166.70 ± 4.20	167.30 ± 4.57	0.71
Weight (kg)	69.00 ± 7.36	68.60 ± 7.60	69.60 ± 5.54	0.74
BMI	26.30 ± 2.20	26.80 ± 2.30	26.78 ± 2.21	0.65

Table 2 presents the proprioception of hip joint, data for the three study groups. To examine baseline differences, a one-way analysis of variance (ANOVA) was conducted for the pre-test scores, revealing no significant differences between the groups. To assess within-group changes from pre-test to post-test, paired t-tests were performed. The results indicated that both the water exercise and combined exercise (water and Pilates) interventions significantly improved proprioception of hip joint compared to the pre-test period. No such improvement was observed in the control group, confirming the effectiveness of the interventions. Among the groups, the combined exercise group (water and Pilates) demonstrated the most substantial improvement in proprioception of hip joint.

Table 3: Within-Group Differences in the Proprioception Variable

Variable	Group	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Pre- and post-test difference test	t-value	Statistical significance (P-value)
Proprioception	Aquatic therapy	10±0.18	0.10±7	4	0.019	0.001*
	Combined therapy	0.41±11	0.12±4	7	0.035	0.001*
	Control	0.50±10	0.30±11	1	2.10	0.78

***** Statistical Significance

To assess the differences between groups before and after the interventions (water exercises and combined exercises involving water and Pilates), one-way ANOVA and repeated measures analysis were conducted. The results indicated that the covariance matrices related to proprioception of hip joint were not significantly different ($p \geq 0.05$), confirming that the assumption of homogeneity of covariance was satisfied. Therefore, the chosen statistical test was appropriate for the final analysis

of the proprioception data (Table 3). Additionally, Levene's test revealed significant differences in error variance between groups. However, the results of Mauchly's sphericity test supported the assumption of sphericity. Considering the significant interaction effect between time and group, it was inferred that the changes in proprioception over time varied by group. In other words, the pattern of change in angular reconstruction errors differed across the three groups.

Table 4: Results of the Repeated Measures Analysis of Variance for the Proprioception Variable

Variable	Interaction effect of group and time		Effect of group		Effect of time		Levene's test		M-Box test
	P	F	P	F	P	F	Post-test	Pre-test	P
Deep Sensation of the Ankle	0.001	6.30	0.001	25.622	0.001	13.24	0.62	0.68	0.47

***** Statistical Significance

Following the identification of significant differences in the initial analysis, the Bonferroni post hoc test was employed to further investigate group differences with greater precision. The results, summarized in Table 5, indicate that both the water exercise program and the combined program (water and Pilates) significantly reduced reconstruction errors in participants compared to the control group. Furthermore, a significant difference was found between the two intervention groups, with the combined program demonstrating a greater impact on reducing reconstruction errors than the water exercise program alone.

Table 5: Results of the Bonferroni Post Hoc Test for Intergroup Differences

Variable		Hydrotherapy	Combined	Control
Deep Sensation of the Thigh	Hydrotherapy	-	0.001*	0.001*
	Combination	0.001*	-	0.001*
	Control	0.001*	0.001*	-

***** Statistical significance

Discussion

The findings of this study revealed a significant improvement in proprioception of hip joint levels following the application of both aquatic and combined (aquatic and Pilates) exercise programs among the three study groups—control, aquatic exercise, and combined exercise. Notably, measurement errors in proprioception decreased among elderly female participants with a history of hip surgery after engaging in these exercise

interventions. Furthermore, the combined exercise group demonstrated a greater effect size and a more substantial reduction in reconstruction angle errors compared to the aquatic-only group. These results are consistent with prior research by Maxwell et al. (2008), Lo et al. (2010), Sudan et al. (2002), and Roche et al. (2005), although they differ from the findings of Kim et al. (2001), likely due to variations in exercise protocols and participant characteristics.

This study offers valuable insights into the impact of an eight-week aquatic therapy program, with and without Pilates, on proprioceptive of hip joint, abilities in elderly women. Both forms of intervention significantly enhanced proprioception in participants with a history of hip fractures, contributing positively to emotional well-being, body awareness, and overall quality of life. These outcomes support existing literature suggesting that aquatic exercise improves both physical and psychological health in older populations (Kim et al., 2001). The supportive nature of water—offering buoyancy and resistance—may increase participant comfort, engagement, and enjoyment during physical activity (Kim et al., 2013).

Numerous studies have reinforced the benefits of water-based exercises for elderly individuals. For instance, aquatic aerobic therapy has been shown to enhance muscular strength, flexibility, and balance, thereby reducing the risk of falls. Likewise, comparative studies indicate that both Pilates and aquatic exercises effectively decrease pain intensity and disability in individuals with non-specific chronic lower back pain (Bass et al., 2010). These findings collectively highlight a strong consensus in the literature regarding the role of water-based exercises in improving functional abilities and quality of life among older adults.

Aquatic therapy, a form of rehabilitation that uses water for therapeutic exercise, improves proprioception of hip joint through multiple mechanisms. The buoyancy of water minimizes joint stress, allowing individuals to perform exercises with less pain and greater mobility—an advantage especially relevant for those recovering from surgery or dealing with arthritis (Smitz et al., 2012). Warm water further promotes muscle relaxation and improved circulation, supporting tissue healing while reducing discomfort. In addition, hydrotherapy provides a calming atmosphere that helps alleviate anxiety and enhance mental well-being—factors that play a key role in effective recovery (Hartman et al., 2002). The sensory feedback provided by water may also enhance cognitive function and sensory integration, making aquatic therapy a comprehensive approach for addressing both physical and mental health needs. As such, it serves as a holistic tool for improving physical capability while fostering emotional resilience (Gisto et al., 2023).

Pilates, on the other hand, enhances proprioception of hip joint by developing deep body awareness and control through structured exercises focusing on core stability, controlled breathing, and precise movement. At the heart of

Pilates is the 'powerhouse'—the muscles of the abdomen, lower back, and pelvis. Every movement begins with the engagement of these core muscles, especially the transverse abdominis, which is critical for spinal and pelvic stability (Parker et al., 2010). Pilates encourages a mind-body connection through mindful focus and breath control, leading to improvements in physical strength, flexibility, mindfulness, and concentration. With regular practice, Pilates can significantly boost proprioceptive skills, thereby enhancing coordination, posture, and balance.

These findings underscore the importance of individualized exercise programs for older adults. Given the demonstrated benefits of both aquatic therapy and Pilates, healthcare professionals should tailor interventions to the specific preferences, abilities, and health conditions of each patient. Additionally, as some studies suggest the value of complementary interventions for improving balance, future research could explore the integration of additional training methods with aquatic therapy to further enhance outcomes. This study adds to the expanding body of evidence supporting the effectiveness of aquatic and Pilates-based interventions in improving proprioception of hip joint and overall well-being in elderly women. Despite the encouraging results, further research is warranted to fully understand their potential across diverse health outcomes. In particular, the nuanced effects on balance observed here call for continued investigation into how these exercise modalities can be further optimized for older adults.

Conclusion

In conclusion, the results of this study demonstrated that the combined exercise program produced a more significant reduction in reconstruction error (proprioception) compared to water-based exercises alone. It is recommended that coaches, occupational therapists, corrective movement specialists, and sports physiotherapists incorporate the combined hydrotherapy and Pilates approach into rehabilitation plans, adapting it to the specific needs and abilities of this population.

References:

- Babaei Bonab, S. (2021). The Effect of Eight Weeks of Aqua Therapy on Back Pain, Body Composition and Motor Function of Inactive Elderly Women. The Scientific Journal of Rehabilitation Medicine, 10(4), 0836-847.
- Bartels, E. M., Juhl, C. B., Christensen, R., Hagen, K. B., Danneskiold-Samsøe, B., Dagfinrud, H., & Lund, H. (2016). Aquatic exercise for the treatment of knee and hip osteoarthritis. Cochrane database of systematic reviews**.(**3).
- Busse PJ, Mathur SK. Age-related changes in immune function: effect on airway inflammation. J Allergy Clin Immunol. 2010;126:690–699; quiz 700-701. - PMC
- Etesami, A. S., Zolaktaf, V., & Esmaeili, H. (2022). Comparison of the effect of **8**weeks of land exercise therapy and hydrotherapy on functional activities of elderly women with knee osteoarthritis. Iranian Journal of Ageing,

17(2), 0154-169 .

- Fisher AA, Davis MW, Rubenach SE, Sivakumaran S, Smith PN, Budge MM. Outcomes for older patients with hip fractures: the impact of orthopedic and geriatric medicine cocare. J Orthop Trauma. 2006;20:172–178; discussion 172-178. - PubMed
- Garcia, M., Firek, M., Zakhary, B., Brenner, M., Hildebrand, F., & Coimbra, R. (2020). Severe pelvic fracture in the elderly: high morbidity, mortality, and resource utilization. The American Surgeon, 86(10), 1401-1406
- Gisto, L., Ribeiro, D., Avelino, P., Costa, H., & Kiefer, K. (2023). Effects of the pilates method on the pelvic floor muscles: a systematic review. Manual Therapy, Posturology & Rehabilitation Journal, 021
- Hartmann B, Junger A, Klasen J, Benson M, Jost A, Banzhaf A, Hempelmann G. The incidence and risk factors for hypotension after spinal anesthesia induction: an analysis with automated data collection. Anesth Analg. 2002;94:1521–159, table of contents. - PubMed
- Ho HH, Lau TW, Leung F, Tse HF, Siu CW. Peri-operative management of anti-platelet agents and anti-thrombotic agents in geriatric patients undergoing semi-urgent hip fracture surgery. Osteoporos Int. 2010;21:S573–S577. - PMC - PubMed
- Joolaei, N., Bagherli, J., & Sanatkaran, A. (2017). The effects of regular pilates exercise on long-term and short-term memory of the elderly. Aging Psychology, 3(2), 0147-157
- Kim WY, Han CH, Park JI, Kim JY. Failure of intertrochanteric fracture fixation with a dynamic hip screw in relation to pre-operative fracture stability and osteoporosis. Int Orthop. 2001;25:360–362. - PMC - PubMed
- Kim, S. B., & O'sullivan, D. M. (2013). Effects of aqua aerobic therapy exercise for older adults on muscular strength, agility and balance to prevent falling during gait. Journal of physical therapy science, 25(8), 923-927.
- Kucia, K., Koteja, A., Rydzik, Ł., Javdaneh, N., Shams, A., & Ambroży, T. (2024). The Impact of a 12-Week Aqua Fitness Program on the Physical Fitness of Women over 60 Years of Age. Sports, 12(4), 105.
- Lo IL, Siu CW, Tse HF, Lau TW, Leung F, Wong M. Pre-operative pulmonary assessment for patients with hip fracture. Osteoporos Int. 2010;21:S579–S586. - PMC - PubMed
- Maxwell MJ, Moran CG, Moppett IK. Development and validation of a preoperative scoring system to predict 30 day mortality in patients undergoing hip fracture surgery. Br J Anaesth. 2008;101:511–517. - PubMed
- Mi, M., Kanakaris, N. K., Wu, X., & Giannoudis, P. V. (2021). Management and outcomes of open pelvic fractures: an update. Injury, 52(10), 2738-2745 .

- Moja L, Piatti A, Pecoraro V, et al. Timing matters in hip fracture surgery: patients operated within 48 hours have better outcomes. A meta-analysis and meta-regression of over 190,000 patients. PLoS ONE 2012;7:e46175–5.
- Moreira, N. B., da Silva, L. P., & Rodacki, A. L. F. (2020). Aquatic exercise improves functional capacity, perceptual aspects, and quality of life in older adults with musculoskeletal disorders and risk of falling: A randomized controlled trial. Experimental gerontology,142, 0111135.
- Mousavi Sadati, S. K., & Behdari, R. (2022). Comparison of the effect of selected Pilates exercises, Traband training and weight training on strength and flexibility in elderly women. Journal of Sports Physiology and Athletic Conditioning, 4(4), 35.
- Parker MJ, Handoll HH. Gamma and other cephalocondylic intramedullary nails versus extramedullary implants for extracapsular hip fractures in adults. Cochrane Database Syst Rev 2010;9:CD000093–3.
- Piccione, F., Maccarone, M. C., Cortese, A. M., Rocca, G., Sansubrino, U., Piran, G., & Masiero, S. (2021). Rehabilitative management of pelvic fractures: a literature-based update. European Journal of Translational Myology, (3)31.
- Roche JJ, Wenn RT, Sahota O, Moran CG. Effect of comorbidities and postoperative complications on mortality after hip fracture in elderly people: prospective observational cohort study. BMJ. 2005;331:1374. - PMC - PubMed
- Rodríguez-Merchán EC. Displaced intracapsular hip fractures: hemiarthroplasty or total arthroplasty? Clin Orthop Relat Res. 2002;(399):72–77. - PubMed
- Ružić, S. (**2020**). The Effects of Pilates With a Swiss Ball Program on Flexibility in Female College Students. Facta Universitatis, Series: Physical Education and Sport, 0439-446
- Saudan M, Lübbeke A, Sadowski C, Riand N, Stern R, Hoffmeyer P. Pertrochanteric fractures: is there an advantage to an intramedullary nail?: a randomized, prospective study of 206 patients comparing the dynamic hip screw and proximal femoral nail. J Orthop Trauma. 2002;16:386–393. - PubMed
- Shiga T, Wajima Z, Ohe Y. Is operative delay associated with increased mortality of hip fracture patients? Systematic review, meta-analysis, and meta-regression. Can J Anaesth. 2008;55:146–154. - PubMed
- Smeets SJ, Poeze M, Verbruggen JP. Preoperative cardiac evaluation of geriatric patients with hip fracture. Injury. 2012;43:2146–2151. - PubMed
- Taylor, N. F., Rimayanti, M. U., Peiris, C. L., Snowdon, D. A., Harding, K. E., Semciw, A. I., ... & Shields, N. (2024). Hip fracture has profound psychosocial impacts: a systematic review of qualitative studies. Age and

Ageing, 53(9), afae194.

- Vidán M, Serra JA, Moreno C, Riquelme G, Ortiz J. Efficacy of a comprehensive geriatric intervention in older patients hospitalized for hip fracture: a randomized, controlled trial. J Am Geriatr Soc. 2005;53:1476–1482. - PubMed