The Effect of Wuqinxi Exercise Therapy on Rehabilitation of Patients with Hip Osteoarthritis: A Cluster Randomised Controlled Feasibility Trial

Siyu Zhou[a] and Yu Tie[*]

School of Physical Education, Liaoning Normal University, Dalian 116029, Liaoning, China

[a]980994014@qq.com
[*]Corresponding author: tieyu@lnnu.edu.cn

Abstract. Objective: This study aims to investigate the therapeutic impact and underlying mechanisms of Wuqinxi (WQX) exercise therapy on hip osteoarthritis (HOA).

Methods: Sixty patients diagnosed with HOA were randomly allocated into two groups, each comprising 30 patients. The control group received standard conservative treatment, while the observation group underwent traditional conservative treatment supplemented with the inclusion of WQX exercise therapy. WQX is a traditional Chinese physical activity that replicates five distinct animal movements. Both groups participated in a six-minute walk test (6MWT) and a 10-meter walk test (10MW) before and after a 12-week treatment. Additionally, visual analog scale (VAS) scores were assessed.

Results: Following 12 weeks of treatment, notable improvements in the 6MWT, 10MW, and VAS scores were observed in both groups. Significantly, the observation group demonstrated more substantial improvements compared to the control group ($p<0.05$).

Conclusion: The integration of conventional conservative treatment with simple WQX exercise therapy proves to be an effective approach for managing hip osteoarthritis. This approach is deserving of wider adoption in clinical practice.

Keywords: Wuqinxi exercise, Hip osteoarthritis, older adults, exercise therapy, rehabilitation effect.

1 Introduction

Hip osteoarthritis (HOA) is a chronic condition affecting the hip joint, characterized by articular cartilage degeneration and secondary bone hyperplasia [1]. It primarily afflicts older individuals, with a higher prevalence among men. The precise cause of primary osteoarthritis remains elusive. This ailment is a protracted, progressive pathological process associated with age, heredity, weight, and constitution, typically afflicting middle-aged and older adults over 50 [2]. However, secondary osteoarthritis can

F. Zeng et al. (eds.), *Proceedings of the 2024 7th International Conference on Humanities Education and Social Sciences (ICHESS 2024)*, Advances in Social Science, Education and Humanities Research 887,
https://doi.org/10.2991/978-2-38476-323-8_104

manifest in younger and middle-aged individuals and may result from trauma, inflammation, cumulative wear, joint deformities, injuries, or congenital conditions. A prominent clinical symptom is joint pain, intensifying with prolonged activity and subsiding with rest [3]. Weather changes and cold can exacerbate this pain, which may radiate to the outer buttocks, groin, inner thighs, and sometimes to the knees. Some patients experience morning stiffness, characterized by joint stiffness and tightness upon waking, which typically dissipates with activity. Concurrently, patients may exhibit joint mobility issues, muscle weakness, muscle atrophy, soft tissue contractures, joint effusion, bone hyperplasia, cartilage degradation, joint deformities, limited hip extension, internal and external rotation, and restricted mobility. Many patients also experience varying degrees of limping, with some becoming incapacitated or bedridden. Anxiety and depression are common comorbidities.

Current non-pharmacological clinical treatments for hip osteoarthritis predominantly include patient education, physical therapy, weight management, self-directed exercises, assistive devices, and traditional Chinese acupuncture. Pharmacological interventions involve the use of anti-inflammatory and analgesic drugs, as well as intra-articular injections [4]. However, despite the array of conservative treatment methods, their efficacy is often limited [5]. Consequently, hip replacement surgery is frequently considered for those in the advanced stages of the disease, although it is costly and beyond the means of many patients. Furthermore, once hip osteoarthritis sets in, the associated pathological changes are irreversible [6,7]. Therefore, the primary goal of treatment is to alleviate or minimize symptoms as much as possible, thus delaying the progression to advanced stages and allowing patients to maintain their daily functionality. Exercise therapy has shown promise in enhancing overall or local motor function, thereby contributing to preserving bodily function or postponing functional decline.

Wuqinxi (WQX) Qigong is a traditional health practice developed by the renowned physician Hua Tuo during the Eastern Han Dynasty (25 – 220 AD) [8]. Also known as Five-Animal Training, Wuqinxi is a widely practiced form of Chinese Qigong rooted in the principles of I-Ching and Traditional Chinese Medicine [9]. Comprising ten distinctive movements, including "Lifting tiger paws," "Catching prey," "Colliding with antlers," "Running like a deer," "Twisting the waist like a bear," "Shaking like a bear," "Lifting a monkey's claws," "Picking fruits," "Stretching upward," and "Flying like a bird" [10,11], Wuqinxi training has been demonstrated to significantly enhance overall bodily function and increase joint strength, density, balance, and flexibility in the context of chronic diseases [12].

In this study, the observation group implemented a simplified WQX exercise therapy in conjunction with conventional conservative treatments, capitalizing on the soft, gentle, and easy-to-learn characteristics of WQX movements. These features make WQX an ideal choice for patients due to its gentle nature, light and slow movements, and adaptability [13]. Furthermore, WQX has the added benefit of mood regulation and relaxation, which can help alleviate anxiety and depression in patients. Moreover, compared with other physical therapy methods, the WQX exercise therapy is not boring and full of fun, which is easy for patients to adhere to.And there are fewer experiments studying the therapeutic effects of WQX on HOA.Based on these, we designed

this study.The primary objective of this research is to investigate the therapeutic effects and mechanisms of a 12-week home-based WQX training program for individuals with hip osteoarthritis (HOA).

2 Data and Methods

2.1 General Information

The sample size was calculated by G.power and required 27 subjects per group.So sixty patients diagnosed with hip osteoarthritis were recruited for this study from the Second Hospital of Dalian Medical University between March 2021 and April 2023. The patients were divided into two groups: the observation group and the control group, each comprising 30 participants. The allocation to these groups was based on whether they received Wuqinxi (WQX) exercise therapy as a rehabilitation treatment.Randomized grouping was accomplished by computer by a researcher not involved in either participant recruitment or administration of outcome measures to ensure concealment.In the observation group, 16 were male and 14 were female, with ages ranging from 47 to 73 years (mean age: 63.07±6.30 years). The control group consisted of 18 males and 12 females, aged between 46 and 71 years (mean age: 60.67±7.91 years). No statistically significant differences were observed between the two groups in terms of gender composition, age, disease severity, joint mobility, and prior history of trauma ($P > 0.05$).

2.2 Inclusion Criteria

(1) Patients diagnosed with hip osteoarthritis through laboratory and imaging examinations. (2) Patients free from critical comorbidities. (3) Patients willing to participate and able to tolerate the experiment. (4) Patients with sufficient cognitive capacity to cooperate with healthcare providers in treatment and experimentation. (5) Patients residing in proximity to the hospital for convenient data collection. (6) Patients with a reliable support system to facilitate regular training.

2.3 Exclusion Criteria

(1) Individuals with severe infections or profound debility. (2) Patients with severe hypertension or heart disease. (3) Patients with dermatomyositis, joint instability, or joint dislocation. (4) Patients with advanced hip joint osteoarthritis, precluding completion of the experiment. (5) Patients who could not effectively participate for various reasons, including remote residency, scheduling conflicts, etc.

2.4 Methods

The control group received a combination of non-pharmacological and pharmacological treatments. Non-pharmacological measures encompassed patient education,

self-regulation, medical counseling, personal care guidelines, avoidance of strenuous exercise, and addressing depression and anxiety. Based on individual patient needs, weight management, the use of canes and crutches to reduce joint stress, and altering the negative gravitational axis were implemented. Pharmacological treatment consisted of symptom-driven administration of anti-inflammatory, analgesic, and blood-circulation-enhancing medications. Additionally, injections of sodium hyaluronate into the joint cavity were administered to lubricate the joint and alleviate pain. The vast majority of patients in the control group of this study were treated with daily pain medication in the morning.

The observation group received simple WQX exercise therapy in conjunction with the control group's treatment. The WQX exercise plan was developed in collaboration with experienced WQX instructors and orthopedic surgeons, with modifications made to adapt it to the needs of hip osteoarthritis patients. Patients in the observation group received systematic training until they attained proficiency in the simple WQX exercises. Escorts accompanied patients in the observation group for training sessions at least five times per week. Medical staff maintained detailed training records, and patient escorts recorded daily training to ensure the quality and consistency of training. The researchers conducted regular follow-ups and supervision.At the end of the study, there was no follow-up of all subjects.

The study received ethical approval from the Liaoning Normal University's Ethics Committee(Reference number:LL2024035), and all procedures adhered to the ethical guidelines outlined in the World Medical Association's Declaration of Helsinki.Written informed consent was obtained from all participants before enrollment.

The details are as follows: the simple five poultry play is divided into five plays; There are two types of tiger play, respectively, sitting in the cave and carrying claws (repeated 3 times around) and the tiger lying cave (left and right each type, each type is done once); There are two types of deer play, respectively, elk waist (left and right each style, each style do once) and neck transport (left and right each style, each style do 3 times); Bear play has two styles, respectively, black bear paw probe (left and right, repeated3 times per style) and silly bear shake body (left and right, repeated 3 times per potential); There are two types of ape play, namely, white ape jumping (left style twice, right style once) and white ape turning (on tiptoe 6 steps for a week) and grasping left and jumping right ; There are three types of bird play, namely, flying crane wings (left and right, repeated 3 times per style), group crane body cleaning(left and right, repeated 3 times per style), white crane flying (repeated 3 times on left and right, in the simple five-fowl play in place practice) or shaking wing (repeated 6 times, in the simple five-fowl play live practice)[14-16].The above movements are practiced 5-6 times, twice a day, following the practice principle from easy to difficult step by step. Simple WQX in the movement to ease the main, soft more just less, relax the muscles and bones, mainly the internal training of the viscera, to facilitate the Qi and blood, disease is not caused, the movement is small, simple and easy to learn, safe and reliable, help to regulate the mood, calm the mind, eliminate distractions, relax the muscles.

2.5 Exercise Protocol

The simple WQX exercises consisted of five poultry movements: two tiger, two deer, two bear, two ape, and three bird movements. These movements were practiced 5-6 times daily, twice a day, following a progressive approach from easy to challenging. Simple WQX exercises primarily focused on gentle and smooth motions to relax muscles and bones, enhance internal organ functioning, promote blood circulation, maintain safety, and regulate mood and focus.

2.6 Outcome Measures

Both groups underwent a 6-minute walk test (6MWT) and a 10-meter walk test (10MW) before and 12 weeks after treatment. Visual Analog Scale (VAS) scores were recorded for both groups before and after the 12-week treatment period. The VAS score, ranging from 0 to 10, quantified pain severity, with higher scores indicating more intense pain. [17]

2.7 Blinding

Patients will be unblinded to study groups.Patients will be informed that this research will test the effect of Wuqinxi exercise therapy on rehabilitation of patients with hip osteoarthritis.However,the assessors of these outcomes are blinded to group names.

2.8 Statistical Analysis

Statistical analysis was conducted using SPSS 26.0 software. Shapir–Wilk tests were used for a normality of distribution test; when the main analysis variables did not show a normal distribution, a nonparametric analysis was performed.Otherwise,data was analyzed using an independent t-test.Measurement data were presented as mean ± standard deviation (mean ± SD), and a T-test was employed. A significance level of $P < 0.05$ was considered statistically significant.

3 Results

No subjects were lost during follow-up. And there were no missing data at all in this study.

3.1 Comparison of 6MWT before and after Treatment between the Two Groups

Before and after treatment, the 6MWT results were (505.37±19.11) m in the observation group and (505.93±19.86) m in the control group, showing no statistically significant difference ($p>0.05$). After treatment, the 6MWT distance for the observation group significantly improved to (526.40±19.38) m, surpassing the control group's

post-treatment 6MWT distance of (509.67±20.55) m, with a statistically significant difference ($p<0.05$). See Table 1.

Table 1. Comparison of 6MWT between the two groups before and after treatment

Group	Pre-treatment mean	Post-treatment mean	P value
OG	505.45±19.23 (m)	526.65±19.59 (m)	0.000
CG	505.95±20.45 (m)	509.55±20.63 (m)	0.000
P value	0.163	0.000	

OG, Observation group; CG, Control group;6MWT,six-minute walk test.

3.2 Comparison of 10MW before and after Treatment between the Two Groups

Before treatment, the 10MW test results were (0.70±0.07) m/s in the observation group and (0.71±0.06) m/s in the control group, with no statistically significant difference ($p>0.05$). After treatment, the 10MW test results significantly improved in the observation group to (1.50±0.10) m/s, while the control group showed a post-treatment 10MW result of (0.90±0.06) m/s, with a statistically significant difference ($p<0.05$). See Table 2.

Table 2. Comparison of 10MW between the two groups before and after treatment

Group	Pre-treatment mean	Post-treatment mean	P value
OG	0.71±0.07(m/s)	1.50±0.10(m/s)	0.000
CG	505.95±20.45 (m)	0.90±0.64(m/s)	0.000
P value	1.000	0.000	

OG, Observation group; CG, Control group;10MW,10-meter walk.

3.3 Comparison of VAS Scores before and after Treatment between the Two Groups

The VAS score before treatment was (7.07±0.52) in the observation group and (7.10±0.61) in the control group, indicating no statistically significant difference ($p>0.05$). After treatment, the VAS score for the observation group significantly decreased to (2.70±0.65), which was lower than that of the control group (4.70±0.79), with a statistically significant difference ($p<0.05$). See Table 3.

Table 3. Comparison of VAS scores between the two groups before and after treatment

Group	Pre-treatment mean	Post-treatment mean	P value
OG	7.05±0.51	2.70±0.66	0.000
CG	7.10±0.64	4.65±0.81	0.000
P value	0.330	0.000	

OG, Observation group; CG, Control group;VAS scores,visual analog scale scores.

4 Discussion

HOA is characterized by recurrent episodes and difficulty in radical treatment.The commonly used clinical treatments include medication, surgery, physical therapy and rehabilitation exercise therapy.Research on rehabilitative exercise therapy is progressively advancing.Bennell et al. found that regular rehabilitation exercise training can improve the functional status of HOA-related organs, such as improving muscle strength, joint mobility, proprioception, balance, and cardiovascular function[18].Li R et al. found that TaiChi training had an adjunctive effect on the rehabilitation of patients with hip osteoarthritis[19].It can be seen that there are many studies on the rehabilitative effects of other physical therapies on HOA, but very few studies on the WQX exercise therapy, so this experiment investigated the rehabilitative effects of WAPT physical therapy on HOA.Specifically as follows.

During the course of hip osteoarthritis (HOA), the decline in lower limb muscle strength contributes to diminished hip stability and movement ability, thereby exacerbating clinical symptoms in patients [20]. Lower limb strength training can effectively enhance muscle strength, ultimately improving hip joint stability and mobility, thus retarding the progression of osteoarthritis (OA). Wuqinxi exercises (WQX) feature movements, such as the half squat in the tiger play and single-leg support in the bird play, which can bolster lower limb muscle strength [21]. As a result, simple WQX can effectively augment lower limb muscle strength and slow the progression of HOA [22].

Patients afflicted with HOA often exhibit compromised lower limb balance, increasing the risk of falls. In an attempt to mitigate this risk, patients tend to reduce their walking speed during daily activities, which, though reducing the risk of falls, significantly impairs their daily lives. Therefore, enhancing the lower limb balance of HOA patients becomes imperative in preserving their daily functionality. Simple WQX encompasses movements, such as one-leg support and weight-shifting between legs, which can significantly improve lower limb balance [23]. Consequently, the practice of simple WQX contributes to better balance, reducing the risk of falls and assisting patients in maintaining their daily lives [19].

The proprioception of the hip joint plays a pivotal role in maintaining body balance, controlling joint movement, coordinating muscle forces, and correcting body posture [24,25]. HOA patients often experience a decline in hip proprioception. Notably, many movements in simple WQX exercises have the potential to modify joint loading and sensory input by shifting the center of gravity and facilitating flexion and extension. This, in turn, enhances the proprioceptive ability of the hip joint and retards the progression of the disease in HOA patients [19].

In the course of HOA, patients often suffer from joint soft tissue contractures, cartilage damage, ligament tightening, and other conditions leading to reduced joint motion and mobility impairments, all of which have a considerable impact on daily activities. Simple WQX includes numerous lower limb ring rotations and stretching movements that effectively stretch ligaments and enhance joint flexibility. This, in turn, promotes improved hip motion and, consequently, delays the progression of HOA [19].

Inflammatory responses play a crucial role in the pathological mechanism of HOA. In the context of joint inflammation, cells secrete pro-inflammatory factors that damage joint cartilage and induce joint pain. Consequently, the author's speculation that simple WQX can reduce the inflammatory response, lower the secretion of pro-inflammatory factors, alleviate joint cartilage damage, reduce joint pain, and enhance the management of HOA symptoms seems well-founded.

The results of this study indicate a significant improvement in walking ability, walking speed, and reduced hip pain in patients with hip osteoarthritis after 12 weeks of treatment. This improvement is particularly evident in the observation group of patients who underwent simple WQX in conjunction with conventional conservative treatment, compared to the control group of patients who solely received traditional conservative treatment.

Of course this study has some shortcomings.The process of rehabilitation training of patients in the experimental group of this experiment in the process of rehabilitation training of WQX is not supervised by professional rehabilitation personnel, so the quality of training of individual patients can not be guaranteed, which will affect the effect of rehabilitation. At the same time the experimental data obtained by calculating the VAS scores will be disturbed by the experimental subjects themselves.These may cause bias in the experimental results of this experiment. Finally, the sample size of this study was relatively small and the number of observations was few. Although this does not affect the main findings of the present study, but may not be able to fully reveal the rehabilitative effect of WQX exercise therapy on patients with HOA,We will expand the sample size and the number of observations for further in-depth analysis.

5 Conclusions

In comparison to conventional conservative treatments, the incorporation of a straightforward Wuqinxi (WQX) exercise therapy has demonstrated a significant positive impact on the rehabilitation of patients with hip osteoarthritis. Following a 12-week treatment regimen, individuals with hip osteoarthritis exhibited marked enhancements in their walking ability and speed, coupled with a noticeable reduction in hip pain. Consequently, the amalgamation of conventional conservative treatments with uncomplicated WQX exercise therapy represents a promising approach for the treatment of hip osteoarthritis that warrants broader adoption in clinical settings [18, 26-28].

Conflicts of Interest

It is worth noting that no conflicts of interest or funding support are associated with this study.

Data Source Statement

The data sources are true and available.

References

1. Hermann W, Lambova S, Muller-Ladner U. Current treatment options for osteoarthritis. Curr Rheumatol Rev. 2018;14(2):108-116.
2. Wright NC, Looker AC, Saag KG, et al. The recent prevalence of osteoporosis and low bone mass in the United States based on bone mineral density at the femoral neck or lumbar spine. J Bone Miner Res. 2014;29:2520–6.
3. Jevsevar DS, Brown GA, Jones DL, et al. The American Academy of Orthopaedic Surgeons evidence-based guideline on the treatment of osteoarthritis of the knee, 2nd edition. J Bone Joint Surg Am. 2013;95(20):1885-1886.
4. Escalante Y, Garcia-Hermoso A, Saavedra JM. Effects of exercise on functional aerobic capacity in lower limb osteoarthritis: a systematic review. J Sci Med Sport. 2011;14(3):190-198.
5. Zhang W, Nuki G, Moskowitz RW, Abramson S, Altman RD, Arden NK, et al. OARSI recommendations for the management of hip and knee osteoarthritis: part III: changes in evidence following a systematic, cumulative update of research published through January 2009. Osteoarth Cart. 2010;18:476–99. doi:10.1136/ard.2009.113100.
6. Crandall CJ, Newberry SJ, Diamant A, et al. Comparative effectiveness of pharmacologic treatments to prevent fractures: an updated systematic review. Ann Intern Med. 2014;161:711–23.
7. Kanis JA, Svedbom A, Harvey N, et al. The osteoporosis treatment gap. J Bone Miner Res. 2014;29:1926–8.
8. Zhou Yang, Li Jiyuan. Comparative study of Hua Tuo Wuqinxi and fitness Qigong Wuqinxi. Liaoning Sport Science and Technology. May 2022; Vol. 44, No. 3. DOI: 10.13940/j.cnki.lntykj.2022.03.013.
9. Zhang F, Bai YH, Zhang J. The influence of "wu qin xi" exercises on the lumbosacral multifidus. Journal of Physical Therapy Science. 2014;26(6):881–884.
10. Yuan-jian L, Yan-jun C, Wei F, et al. Clinical research on the influence of Wuqinxi exercise on knee-joint muscle strength and balance capacity in middle-aged and elderly women. SHJ TCM. 2017;51:73–76.
11. Li XF. Research on the Development of Our Health Qigong Associations in the Present Stage [master degree] [master's thesis]. Beijing: Beijing Sport University; 2008.
12. Skrypnik D, Bogdański P, Mīdry E, et al. Effects of endurance and endurance strength training on body composition and physical capacity in women with abdominal obesity. Obes Facts. 2015;8(3):175–187.
13. Wu Jincang, Zhang Xiaoyuan, Yan Sicheng, Ye Yang. Research Progress of Fitness Qigong Wuqinxi in the Treatment of Knee Osteoarthritis. Modern Traditional Chinese Medicine. July 2021; Vol. 41, No. 4. DOI: 10.13424/j.cnki.mtcm.2021.04.002.
14. Simple Hua Tuo Wuqinxi. TCM HEALTHY LIFE-NURTURING. 2017;2.
15. Simple Hua Tuo Wuqinxi. TCM HEALTHY LIFE-NURTURING. 2017;3.
16. Simple Hua Tuo Wuqinxi. TCM HEALTHY LIFE-NURTURING. 2017;4.
17. Gu Zheng-rong, Wang Hai-peng, Yan Jia-hua, Liu Yun-ji, Xu Jing, Zheng Hong, Chen Xue-ming. Analysis of the Survival Quality of Hip Osteoarthritis Patients and its Risk

Factors. Progress in Modern Biomedicine. July 2015.
doi: 10.13241/j.cnki.pmb.2015.21.035.
18. Bennell KL,Hinman RS. A review of the clinical evidence for exercise in osteoarthritis of the hip and knee[J]. J Sci Med Sport,2011,14(1):4 -9.
19. LI Ran, ZHANG Yuxin, FENG Suomin. Effect of Taijiquan combined with muscle strength training on rehabilitation of patients with hip osteoarthritis.Journal of Clinical and Experimental Medicine Vol.15, No.11 Jun.2016. DOI:10. 3969 /j. issn. 1671 -4695.2016.11. 006.
20. Yu Ying. Network Meta-analysis of Four Kinds of Traditional Chinese Fitness Exercises in the Treatment of Osteoporosis in the Elderly. China Sport Science and Technology. 2020; Vol. 56, No. 9: 37-44. DOI: 10.16470/j.csst.2020115.
21. Li Jingya, Cheng Liang. The effect of Taichi and resistance training on osteoarthritis symptoms of the elderly and exercise capacity. Chinese Journal of Rehabilitation Medicine. 2019; 34(11): 1304-1309.
22. Jegu AG, Pereira B, Andant N, et al. Effect of eccentric isokinetic strengthening in the rehabilitation of patients with knee osteoarthritis: Isogo, a randomized trial. Trials. 2014;15(1):1-6.
23. Ma Qi, Kong Jiayang, Zang Guangyue. A Meta-Analysis of the Effect of Fitness Qigong on the Improvement of Balance Ability of the Elderly. Contemporary Sports Technology. 2021; Vol. 11, No. 31. DOI: 10.16655/j.cnki.2095-2813.2104-1579-0525.
24. Kapetanakis S, Dermon A, Gkantsinikoudis N, et al. Acetabular labrum of hip joint in osteoarthritis: a qualitative original study and a short review of the literature. J Orthop Surg (Hong Kong). 2017;25(3):2309499017734444.
25. Ceredig RA, Pierre F, Doridot S, et al. Peripheral delta opioid receptors mediate duloxetine antiallodynic effect in a mouse model of neuropathic pain. Eur J Neurosci. 2018;48(5):2231-2246.
26. He Bing, Zhang Yong-hui, Shi Jian-wei, Zuo Hui-fang, Wang Qi-chao. Application effects of hip abductor muscle exercise combined with quadriceps muscle exercise in the treatment of early knee osteoarthritis. Chin J Bone Joint Injury. December 2022; Vol. 37, No. 12. doi: 10.7531/j.issn.1672-9935.2022.12.005.
27. Zhu Pengzhan, Niu Zhijun. The Application of Various Traditional Exercises in the Treatment of Orthopedic Diseases. Chinese Medicine in Modern Distance Education of China. May 2021; Vol. 19, No. 10. doi: 10.3969/j.issn.1672-2779.2021.10.074.
28. Kangjian, Luoyang, Xiaoyu Wen, Zhihong Zou. Research Progress of Wuqinxi in the Treatment of Orthopedic Diseases. Popular Science & Technology. October 2021; Vol. 23, No. 10.