



Effects of the Low-Calorie Diet and Adapted Physical Activity on Subjects Suffering from Osteoarthritis

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Abstract

Background: Arthrosis is a degenerative disease that affects the cartilage that lines the bones at the level of the joints. This leads to a progressive joint deformity and a limitation in the movements of the joint heads with consequent pain. In Italy about 4 million people are affected by osteoarthritis and this represents 72% of all rheumatic disorders. Unfortunately, there are currently no definitive cures but therapies capable of inducing remission and increasing life expectancy, if diagnosed in time. People who suffer from it are often forced to leave their jobs and face excessive costs for social and health care. The progression of the disease, if not well controlled, affects the progression of quality of life, the frequency of hospitalizations and productivity. Unfortunately, according to the latest data, there are several degenerative conditions of the coxofemoral joint that also affect younger patients. Conservative surgical treatment, possible when the degeneration is modest, aims to stabilize the joint and reduce the overload on the surface.

Objectives: Overweight and obesity can exert a greater load due to weight gain; however, there may be differential systemic effects depending on the degree of fat versus lean mass. From the point of view of biomechanics, joint overload was considered one of the main causes of the onset and progression of osteoarthritis. To minimize the risk of hip osteoarthritis it is important to avoid overweight, the assumption of incorrect postures and excessive and repeated load on the joint. The goal of our study is to demonstrate, through the literature, how a low-calorie diet and physical activity, it is possible to help people with osteoarthritis to find benefit from this debilitating pathology.

Methods: However, there are few studies on how a correct diet is useful or able to reduce inflammation and the various forms of osteoarthritis. Furthermore, the course of the disease involves a rapid increase in pain, muscle-tendon and joint stiffness with consequent loss of range of motion (ROM) and muscle strength, due to the decrease in mobility.

Results: Several studies show how the regular practice of physical exercise can slow down the aggravation of complications, becoming a useful tool to support drug treatment in pain management.

Conclusions: Therefore, although maintenance of daily physical activity is recommended for patients with osteoarthritis, adequate nutrition, particularly a low-calorie or ketogenic diet, is also recommended in order to prevent daily cumulative excessive load on the hip and progression of the osteoarthritis (HOA). This is why it is important, for these patients, the figure of a Dietitian, a Physiotherapist and qualified personnel who evaluate the patient's physical activity in order to preserve functional independence, muscle strength and reduce or remove the complications that this clinical condition can lead.

Keywords: Osteoarthritis; Arthosis; Disability; Low Calorie Diet; Physical Activity

Introduction

Arthrosis (or osteoarthritis) is a chronic degenerative disease that affects the joints, characterized by the progressive loss of the articular cartilage, which physiologically covers them, and its replacement by new bone tissue [1-3], this causes pain and limitation in movement. People who suffer from it are often forced to leave their jobs and face excessive costs for social and health care. The progression of the disease, if not well controlled, affects the

progression of quality of life, the frequency of hospitalizations and productivity [4-6]. According to the Italian Society of Rheumatology (SIR) in Italy about 4 million people are affected by osteoarthritis and this represents 72% of all rheumatic disorders. It affects one in three individuals over the age of 65 and mainly women. Its prevalence, estimated at around 20-30% of the population of developed nations, is growing rapidly worldwide in relation to aging and the increase in risk factors such as obesity and joint trauma

[7]. According to the multipurpose survey on families "Aspects of daily life", carried out annually by the National Statistical Institute (Istat, 2013), osteoarthritis/arthrosis and osteoporosis affect respectively 16.4% and 7.4% of the population, resulting among the most common diseases or chronic conditions in Italy. In addition, more than 300 million people worldwide are affected by this disease that causes disability and pain [8,9]. Osteoarthritis is a multifactorial disease, caused by multiple coexisting causes, which is established in a joint when, due to general or local factors, an imbalance between cartilage resistance and functional stress occurs. Some general factors and local factors are involved in the onset of arthrosis [10-13]. The general factors involved concern

- **Age:** there is a direct correlation with age, in fact it is present in most people over 40 and in almost all of the sixty-year-olds with a peak incidence between 75 and 79 years. It is by far the most important cause of pain and disability from joint diseases. Before the age of 45 the male sex is more affected, after this age the female sex. The prevalence of lesions increases with increasing age.
- **Obesity:** overloads the joints, especially those most responsible for supporting body weight (knees, hips, ankles and lumbar spine) Metabolic (typically Ca²⁺) and/or hormonal (estrogen) alterations
- **Environment:** climate and working conditions above all. Those who carry out jobs or sports that require the repetitive use of a certain joint consequently lead to greater wear and a predisposition to disease.
- **Hereditry:** osteoarthritis can also be a hereditary disease due to a hereditary defect in the production of collagen which therefore predisposes the individual.

Furthermore, there are local factors and concern the altered distribution of mechanical stresses on the joint surface (e.g., due to deviation of the normal load axes as in the valgus knee) and joint alterations produced by inflammatory diseases (e.g. rheumatoid arthritis), traumatic (e.g. Perthes disease), from epiphyseal necrosis, etc. [14,15]. Ultimately, the imbalance can derive from the presence of factors that act abnormally on the load (mechanical stress, obesity, trauma and microtrauma, malformations) or on the cartilage (inflammation, genetic predisposition, metabolic disorders, aging) or on both [16].

Pathological anatomy

As we said earlier, arthrosis mainly affects the articular cartilage. Articular cartilage is an elastic, compressible and deformable tissue formed by rounded cells (chondrocytes) that secrete a substance consisting of elastic fibers and collagen (synovial fluid) formed mainly by water and free of mineral salts, having the dual task: to cushion movements, and ensure the nourishment of the cartilage tissue which, not being vascularized as it lacks blood vessels, obtains the nourishment of its chondrocytes through the phenomenon of diffusion, a slow and much less effective process than blood

circulation. The regenerative capacities of this tissue are very low. The synovial fluid is continuously flowing inside the joint: depending on the movements and loads it is absorbed or released by the cartilages which function as sponges [1-19]. As a consequence of this imbalance there are

- **Cartilage alterations:** narrowing of the joint line (due to thinning of the cartilage with possible cracks where the load is greater)
- **Osteophytes:** neoformation of elongated bone circles (as a result of ossification of the articular cartilage) at the joint surfaces
- **Subchondral osteosclerosis and geodic cavities:** thickening of bone tissue in correspondence with the areas of greatest wear of the cartilage, alternating with areas of rarefaction corresponding to small cavities containing cartilaginous fragments and necrotic trabeculae.
- **Alterations of the synovial membrane:** hypertrophy and thickening of the villi
- **Alterations of the joint capsule:** edema, thickening, fibrosclerosis
- **Joint deformation:** alteration of the physiological shape and axis of the joint heads (in the very advanced stages of the disease).

Symptomatology

The symptomatology of subjects suffering from osteoarthritis concerns pain and functional limitation. Pain is the main symptom that first arises only at the beginning of movement (especially after immobility for several hours such as in the morning), subsides during functional activity and reappears after fatigue (eg in the evening); in the more advanced stages it becomes uninterrupted, disturbing even the night's rest. Functional limitation is an expression of mechanical obstacles (anatomical joint alterations e.g. osteophytes) and of the muscle contracture that is triggered as a defense against pain [20].

Classification

Arthrosis is classified into primary and secondary. We are talking about primary osteoarthritis when it arises without a pre-existing pathology affecting the joint. On the contrary, secondary osteoarthritis arises as a result of one or more factors that have altered the relationships or trophism of the joint heads, such as: congenital or acquired deformities, outcomes of trauma, infectious processes, inflammatory processes (rheumatoid arthritis) and functional overload (e.g., obesity) [21,22].

Main localizations

The person with osteoarthritis is affected by the disease in different parts of the body. Therefore, osteoarthritis can be localized at the hip level, for which we will have arthrosis of the hip or coxarthrosis that affects the joint heads of the hip (acetabular cavity and head of the femur), at the level of the knee, or osteoarthritis

of the knee or gonarthrosis that affects the joint heads of the knee (femoro-tibial joint and patello-femoral joint) and finally can be localized at the vertebral level, so we will talk about vertebral arthrosis, which is distinguished in: in cervical arthrosis, dorsal arthrosis and lumbar arthrosis, depending on the vertebral tract involved [23,24].

Low-calorie diet and arthrosis

A growing number of scientific evidence points out that proper nutrition, the adoption of a healthy lifestyle and the increase in physical activity represent the cornerstones for the prevention of chronic diseases such as osteoarticular ones. The greater the excess body fat, the greater the risk. Arthrosis is a disease characterized by a chronic degenerative process of the joint complex in which clinically evident phases alternate with oligo-asymptomatic phases. The evolution of the disease is slow and functional impotence is rarely reached, which is due to the pain and difficulty of normal joint movement caused by joint deformation. Risk factors are advanced age, female sex, heredity, sedentary lifestyle, obesity, diabetes, hyperuricemia, skeletal malformations and particular work and sports activities [25-27]. This is why, especially in obese patients, it is considered necessary to resort to low-calorie nutritional therapy, in order to reduce weight loss in the short and medium term and put as little burden as possible on the joints affected by arthrosis. A ketogenic diet could be a viable alternative or solution for weight loss in the short to medium term [28]. Therefore, a low-calorie nutritional plan is particularly important in patients in elections for hip and knee replacement surgery, as some studies in the literature show that patients with a body mass index (BMI) higher than normal, have more likelihood of complications during and after surgery, compared to a normal weight patient [29]. In fact, if an obese patient suffering from arthrosis (for example knee osteoarthritis) undergoes a first surgery that involves the insertion of a replacement prosthetic implant, and this same patient will not lose weight by following a low-calorie diet, this excessive weight will cause a failure of the first prosthetic implant and, therefore, this will involve further surgery and this time will be much more invasive [30,31]. Several studies show that nutritional changes influence risk factors for obesity and for the progression of joint disease. In a study published by Maria Grorud Fagerhøi and colleagues [32], it can be seen how personalized dietary advice has led to more respectful food choices in patients with chronic inflammatory joint diseases and consequently also to reduce cardiovascular risk factors. The subject with osteoarthritis, especially if he is over 60 years of age, is a subject who in addition to having the pain and various complications of joint disease, is also more likely to have cardiovascular risks. Therefore, a low-calorie diet that is able to make the subject lose weight can also have beneficial effects on the cardiovascular level [33,34]. Furthermore, an unbalanced diet plan in the daily intake of lipids could increase the risk of developing metabolic syndrome and other musculoskeletal diseases, including osteoarthritis or osteoarthritis (OA). As can be seen from this study by Natalia S. Harasymowicz and colleagues, fatty acids may play a role in joint inflammation and on the pathogenesis of OA,

with effects on joint tissues including cartilage, bone and synovium [35]. Furthermore, in subjects affected by arthrosis, especially in overweight and obese subjects, a predominantly vegetarian and basically low-calorie diet is recommended, as, according to some studies, modern Western diets rich in saturated fatty acids increase inflammation and severity of arthrosis. On the contrary, as this study by Francis Berenbaum and colleagues shows, polyunsaturated fatty acids (PUFA), such as eicosapentaenoic and docosahexaenoic acids, inhibit inflammation and accelerate its resolution [36,37]. The foods to be preferred are those containing sulfur (eggs, asparagus, onions), as a dietary deficiency of amino acids containing sulfur, which are important elements in the extracellular matrix of cartilage, could help restore and prevent further degradation of the cartilage. Over the years there have been substances studied to support the therapy of osteoarthritis in order to slow down the progression and reduce painful symptoms, such as "Glucosamine". In particular, glucosamine sulfate appears to improve the ability of chondrocytes to synthesize glucosaminoglycans, which are important components of joint cartilage, and inhibit some chemical mediators of inflammation [38,39]. But double-blind and placebo-controlled studies have shown a discrepancy on the use of this substance in the resolution of osteoarthritis symptoms, as it appears to be more useful in knee osteoarthritis than in hip arthrosis; therefore only a part of arthritic subjects benefit from it [40,41]. According to this 2005 study by E. Goulet and colleagues [42], "Chondroitin sulfate", which is a derivative of animal cartilage, precursor of glycosaminoglycans, appears less effective than glucosamine sulfate, but is often associated with glucosamine in various supplements used. in osteoarthritis, with a good effect on pain, in particular in knee osteoarthritis. As stated in this study by Jasvinder A. Singh and colleagues, in which chondroitin (alone or in combination with glucosamine) was found to be better than placebo in improving pain in subjects with OA and had lower serious adverse effects than the group control [43]. Foods containing solanine, such as peppers, aubergines, potatoes and tomatoes, should be avoided. However, there are still few studies confirming a relationship between diet composition and osteoarthritis. Furthermore, there are insufficient studies that affirm a protective and effective role of chondroitin sulfate in the treatment of osteoarthritis [44].

Materials and Methods

A systematic search of English-language articles in the PubMed database was performed using the search terms: osteoarthritis, arthrosis, disability, low calorie diet, physical activity. The date range of the research was limited to a period between 1996 and 2022, with the exception of two articles (1989 and 1994) relating to the part on physical activity. The oldest articles referred to research on substances studied in support of osteoarthritis therapy in order to slow down the progression and reduction of painful symptoms, such as "Glucosamine" and "Chondroitin". During our research, only arthritis or osteoarthritis were included as the subject of our study. Clinical cases, rheumatoid arthritis and "gray literature" articles were excluded.

Adapted physical activity (APA)

The course of the disease involves a rapid increase in pain, muscle-tendon and joint stiffness with consequent loss of range of motion (ROM) and muscle strength, due to the decrease in mobility. Despite the pain and functional limitation, there are factors that represent obstacles or challenges to be taken into consideration when trying to set up adapted training programs in patients with this clinical condition, several studies have shown how regular exercise practice can slow down the aggravation of complications by becoming a useful tool to support pharmacological treatment in pain management [45,46]. Unfortunately, there is a misconception that exercise programs can aggravate joint damage and the typical symptoms of pain and fatigue. On the other hand, adapted physical activity must be promoted in this group of people by doctors and health professionals. There are countless studies aimed at evaluating and providing useful parameters of physical work in subjects suffering from osteoarthritis, also in consideration of the fact that, individuals who suffer from it, of the same age and sex, are more likely to incur muscle atrophy and possibility to develop overweight compared to healthy individuals [47]. Physical exercise provides an important contribution in maintaining and increasing muscle strength and aerobic capacity [48,49], by counteracting functional decline; moreover, it alleviates pain and joint stiffness by favoring the management of body weight and body composition, helping to combat comorbidities and contributing to the improvement of mental health and implementing quality of life [50-54]. The exercises recommended for patients suffering from osteoarthritis are of the aerobic type, of strengthening the muscles with resistance exercises, flexibility exercises, postural control and functional exercises [55] (Figure 1).

Several studies state that patients show a rapid deterioration in cardiorespiratory capacity, balance and coordination, with a further deterioration in the quality of life and with an increased risk of loss of autonomy and functional independence [56-58]. Aerobic exercise (walk on dry land, or mild activity in the water), seems to be the one that ensures the greatest results in terms of cardiovascular function, cardiorespiratory fitness and general physical and above all mental well-being; if we add to this a component of muscle strengthening through tone-trophism exercises, the improvements will also be noted on the selective muscular endurance capacity to efforts (measured by handgrip) and on muscle flexibility as already highlighted in a 1989 study [59]. All the benefits mentioned were obtained without an increase in drug therapy, indeed, the patients examined even found that during the 12 weeks of the study the number of painful joints gradually decreased. Flexibility exercises are also important to increase the range of joint movement and to avoid the adverse effects of the disease on the joints [60]. Each type of exercise must be preceded and concluded with an adequate warm-up and cool-down lasting at least 15 minutes. The type of physical exercise must obviously be easy to implement and personalized; the personalization must take into account the subjective abilities of each individual (Table 1).

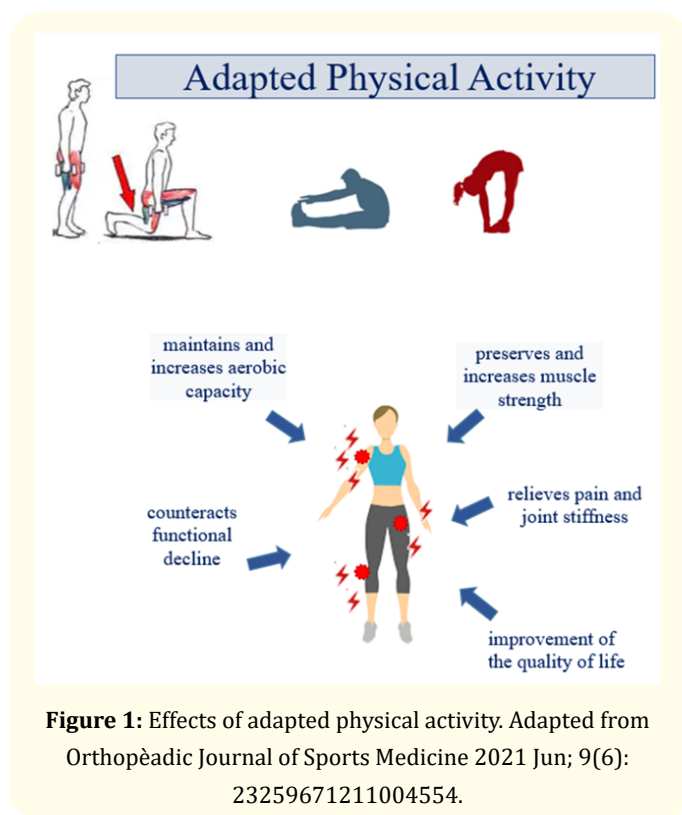


Figure 1: Effects of adapted physical activity. Adapted from Orthopédic Journal of Sports Medicine 2021 Jun; 9(6): 23259671211004554.

	Aerobic exercise	Resistance exercises	Flexibility exercises
Frequency	3-5 days a week	2-3 days a week	Daily
Intensity	Moderate (40-59% VO ₂ R or FCR) or vigorous > 60% VO ₂ R or FCR)	60%-80% 1RM. The initial intensity should be lower (eg: 50% - 60% 1RM) for subjects not used to exercising strength with overloads	Spread across the ROM until you feel tension/stretch without pain. Increase ROM only when pain is minimal or absent
Duration	150 minutes per week for moderate intensity, 75 minutes per week for vigorous intensity, or an equivalent combination of the two	Use values for healthy subjects and modify accordingly (e.g., 8-12 reps for 2-4 sets); include all major muscle groups	Up to 10 repetitions for dynamic movements; static stretch for 10-30 seconds
Type	Activities with low joint stress, such as walking, cycling, swimming, or water exercises	With machinery or without overloads. Exercises using body weight may be appropriate for some individuals	A combination of static and dynamic stretching focused on the major joints
	1RM: Maximum Repetition FCR: Cardiac Reserve Frequency ROM: range of motion VO ₂ R: Oxygen Consumption Reserve		

Table 1: Recommendations for individuals with osteoarthritis, adapted from (A.C.S.M.).

Exercises of high intensity should be avoided during the phases of acute inflammation, in this phase it is advisable to carry out exercises at light intensity respecting all the R.O.M. articulate. Individuals who decide to undertake an adapted physical activity program must be informed of the possibility of experiencing slight muscle or joint pain or discomfort at the end of exercise, especially if the proposed exercises are unfamiliar. It should be borne in mind that these pains tend to occur especially in subjects who have recently approached physical exercise and could also be due to late muscle pain (DOMS). Thanks to the innumerable scientific evidences we can believe that aerobic physical exercise, from walking, to stationary bikes, to dance, to water work [61,62], associated with an adapted program of muscle toning (low impact isometric work or low/medium impact exercises with an adapted ROM or group fitness activities such as Pilates or yoga), can be an effective support to normal therapeutic treatment in patients suffering from pathologies [63], thus discriminating possible complications, such as: disease cardiovascular, fractures and falls [64-67]. The method of carrying out the prescribed activity must ensure the safety of the patient and at the same time the easy implementation of the same, in order to ensure optimal adherence by the patient to the same. The best results were obtained with a minimum of two sessions of adapted physical activity per week, lasting 60 minutes each [68]. It is very important to highlight that patients who exercised under close supervision of qualified personnel, obtained greater benefits and in less time, compared to those who exercised independently in their own home [69].

Conclusion

Currently, there are no curative treatments that can solve arthrosis or osteoarthritis, whose management strategies focus on resolving symptoms through pain relief and arthroplasty. Unfortunately, there are not even specific supplements or foods able to alleviate or cure the symptoms, but the reduction of body weight remains the fundamental rule. Various treatment options are available, including: (1) oral medications: analgesics such as acetaminophen, aspirin, non-steroidal anti-inflammatory drugs (NSAIDs), and opioids; (2) local therapies (in the form of gels or creams): NSAIDs; (3) intra-articular therapies: corticosteroid and hyaluronic acid injections; (4) non-pharmacological methods: physical therapy, aerobic therapy, strengthening exercises, transcutaneous electrical nerve stimulation; and (5) surgical treatments: joint replacement. However, it should be remembered that in outpatient settings, overweight or obese patients often arrive who, despite the efforts, attempts and willingness to follow nutritional therapy, unfortunately cannot carry out regular non-surgical treatments due to the pain caused by the disease. On the other hand, other subjects, despite being able to follow the trained staff to guide them in non-surgical treatments, are unable to observe adequate nutritional therapy, as they are not directed in time to be observed by a dietitian. This could also lead the subject to failure in non-surgical treatments, as excess body weight could hinder the correct execution of the exercises, fatigue and the easy abandonment of the subject to

care and support. Therefore, hence the importance and the need to follow the subject with osteoarthritis by a trained team that includes the specialist doctor, the dietician, the physiotherapist and the qualified personnel for non-pharmacological treatments, in order to remove the symptoms as much as possible. painful and functional impotence, typical of chronic degenerative disease, such as arthrosis. Our hope is to be able to find adequate and accessible treatments for those affected by this pathology. The strength of our study is the inclusion of physical activity as an important element to be advised in these subjects who are living with a debilitating disease, such as arthrosis. However, in this phase of the study, it was not possible to include a sample of subjects as it is still under analysis. The hope for the next study is to demonstrate on a larger sample, the results of the effectiveness of physical activity and a low-calorie diet in support of these subjects, to fully understand the dynamic role of both.

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