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Invited Review
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Exercise approaches in obese individuals with physical limitations

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ABSTRACT

Obesity is a clinical condition characterized by weight gain and a progressively increasing prevalence that poses a significant threat to human health. It may also predispose individuals to numerous chronic diseases. Physical limitations such as musculoskeletal problems (e.g., osteoarthritis and low back pain), spinal cord injuries, hemiplegia, and other comorbidities both increase the development of obesity and make exercise participation more difficult in obese patients. This review summarizes current evidence regarding exercise approaches used in obese individuals with physical limitations and clinically evaluates aerobic, resistance, and flexibility exercises.

Keywords: Aquatic exercise, arm ergometry, elliptical training, obesity, physical limitation, stretching and balance exercises.

Obesity is a clinical condition characterized by excessive adipose tissue accumulation that poses significant health risks not only in adults but also in children and adolescents.[1] The prevalence of obesity is dramatically rising worldwide.[2] In addition to its effects on cardiovascular and metabolic diseases, obesity also has both mechanical and inflammatory effects on the musculoskeletal system, leading to pain, functional limitation, and increased susceptibility to degenerative joint and soft tissue disorders.[3,4]

In obese patients, mobility and endurance decrease, pain and fatigue increase, sleep quality declines, and a vicious cycle of physical inactivity develops. These factors accelerate both the onset and progression of musculoskeletal disorders.[5] Among individuals experiencing pain and movement restriction due to osteoarthritis (OA), reduced physical activity leads to obesity rates as high as 40 to 60%. This vicious cycle is particularly pronounced in patients with knee OA, low back pain, and hip OA.[6] The risk of developing knee OA is two to seven times higher in obese individuals compared to those with normal weight.[7] Similarly, the prevalence of low back pain, hip and ankle pain, and widespread musculoskeletal pain is significantly higher in obese adults. These findings indicate that obesity affects the musculoskeletal system not only through increased biomechanical load but also through inflammatory mechanisms.[3,5]

In patients with physical inactivity sarcopenic obesity is frequently observed due to muscle loss and a sedentary lifestyle.[8] In sarcopenic obesity, the combination of increased fat mass with reduced muscle mass or muscle strength significantly increases the risk of falls, fractures, and functional dependency.[9]

Individuals with physical limitations exhibit reduced daily physical activity and ambulation. This decreases total energy expenditure and leads to weight gain over time. In individuals with spinal cord injury (SCI), basal metabolic rate may decrease by up to 54%, total daily energy expenditure declines, and the prevalence of obesity rises to two to three times that of the general population.[10,11] In patients with SCI, the prevalence of obesity exceeds 66%, and conventional body mass index (BMI) measurements frequently misclassify these individuals.[12]

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Following SCI, patients may experience reduced muscle mass, increased adipose tissue, and metabolic disturbances. Instead of the conventional BMI threshold (≥30 kg/m^2), a value of ≥22 kg/m^2 is recommended for defining obesity in SCI due to dramatic losses in muscle and bone tissue.[13]

Physical limitations (e.g., SCI, advanced OA, neurological disorders, amputation, severe low back pain, and muscle weakness) can significantly increase obesity risk by causing physical inactivity.[10,12,14,15] In obese individuals, musculoskeletal pain, OA, and low back pain further exacerbate kinesiophobia and constitute a strong barrier that prevents physical activity from serving as the cornerstone of obesity treatment.[16,17] Obese individuals with physical limitations represent a unique and challenging patient group in clinical care. These patients face both the systemic health effects of obesity and the mechanical limitations that hinder movement, self-care, and rehabilitation.[17,18]

Exercise principles

Any movement that uses skeletal muscles and requires energy expenditure in daily life is defined as physical activity. In contrast, exercise refers to structured, planned, and repetitive physical activities aimed at maintaining or improving one or more components of physical fitness.[4,5]

Before planning an exercise, an individual's health status, risk factor profile, behavioral characteristics, physical limitations, personal goals, and exercise preferences must be evaluated.[2,16] Conditions that prevent exercise or determine the appropriate exercise modality should be identified. To avoid adverse health events, a comprehensive pre-exercise assessment, including heart rate, blood pressure, and functional capacity measurements, as well as musculoskeletal examination, is essential. In high-risk obese individuals (known coronary artery disease, congestive heart failure, uncontrolled hypertension, or advanced diabetic complications), cardiological evaluation is mandatory before exercise.[2,5,16]

A well-designed exercise prescription for obese individuals defines the exercises that will be performed, as well as the mode, duration, intensity, and frequency, serving as an important complementary element of obesity treatment.[16,17]

Exercise models used in obese individuals are generally classified into three categories: aerobic exercises, resistance exercises, and flexibility and balance exercises. A combined exercise model provides four main benefits: improved cardiovascular endurance through aerobic exercises, increased muscle strength and endurance through resistance training, enhanced joint mobility through flexibility exercises, and reduced injury risk through improved muscle-tendon coordination.[16,17]

A meta-analysis evaluating the effects of different exercise types on physical fitness in overweight or obese adults examined four exercise types: aerobic exercise, resistance exercise, combined (aerobic + resistance) exercise, and high-intensity interval training (HIIT). According to the meta-analysis, aerobic, resistance, combined, and HIIT exercises all significantly increased VO_2max (maximal oxygen uptake) values in overweight/obese adults. Resistance and combined exercises additionally improved muscle strength and functional capacity. Aerobic exercise is the most effective approach for cardiorespiratory improvement, and exercise selection should be individualized based on health status, age, preference, and tolerance.[4]

A systematic review was conducted to identify exercise interventions that improve physical function, weight management, and musculoskeletal pain in obese individuals and guide evidence-based exercise prescriptions for those at risk of OA. Participants performed aerobic exercises (walking, cycling, treadmill, aquatic exercise, and cross-trainer) and resistance exercises (multi-joint, high-intensity, and machine-based). Significant reductions were observed in fat mass and total body weight. The most pronounced results were observed in high-intensity aerobic exercises (70 to 90% of maximal Hearth rate [HRmax]). According to the meta-analysis, high-intensity resistance and aerobic exercises combined produced the strongest effects.[18]

Although exercise therapy remains a fundamental approach in obesity, issues such as joint pain, movement restriction, or musculoskeletal deformities may limit exercise participation. Since participation in conventional exercise is even more limited in obese individuals with physical restrictions, personalized exercise approaches are essential.[2,16,17] Exercise programs for obese individuals with limitations should target pain reduction, metabolic health, functional capacity, muscle strength, balance, and psychological well-being.[16]

Therefore, alternative exercise options that reduce joint load while preserving cardiovascular and metabolic benefits have gained importance for obese individuals with physical disabilities. Aerobic exercise plays a central role in obesity treatment due to its ability to increase energy expenditure and simultaneously affect multiple physiological systems. Therefore, in this patient group, low-impact aerobic exercises (aquatic therapy, arm/leg ergometry, elliptical training, and cycling) and seated activities are critical for preventing obesity. These alternative types of exercises reduce impact forces, provide a safer exercise environment, and help overcome barriers created by physical limitations.[17]

Aerobic exercises in physical limitation

Aerobic exercise is the form of physical activity with the strongest evidence base in public health and clinical medicine. It is the most widely used and clinically validated exercise type in obesity treatment. Due to its ability to increase fat oxidation, improve cardiorespiratory capacity, and enhance functional status, international guidelines recommend aerobic exercise as the first-line approach for obese individuals.[2,16]

Aerobic exercise relies on the rhythmic and continuous activation of large muscle groups and provides the following physiological adaptations: increased VO_2max through enhanced mitochondrial biogenesis, increased stroke volume and improved cardiac output, improved insulin sensitivity, reduction in subcutaneous and visceral fat, decreased systemic inflammation, and improved lipid profile.[15]

The American College of Sports Medicine (ACSM) recommends aerobic exercise as a core component of obesity treatment due to its ability to increase energy expenditure, reduce cardiometabolic risk, and support weight loss. The ACSM defines aerobic exercise prescriptions for obese individuals using the FITT-VP (frequency, intensity, time, type, volume, and progression) model.[17]

For increasing energy expenditure, ACSM recommends aerobic exercise five to seven days per week. Exercising almost daily is considered more effective. Due to joint loading, cardiometabolic risk, and conditioning level, moderate intensity should be the initial choice for aerobic exercise in obese individuals.[16,17] Exercise intensity may be determined using the heart rate recovery (HRR) percentage, %HRmax, metabolic equivalent of task (MET), or Rating of Perceived Exertion (RPE) criteria of the Borg scale.[17]

Criterion	Moderate intensity	High intensity
%HRR	40-59%	60-89%
%HRmax	64-76%	77-95%
MET	3-5.9	≥6
RPE	12-13	14-17

The ACSM defines three duration levels for aerobic exercise in obesity; 150 min/week for minimal health benefit, ≥225–300 min/week for clinically meaningful weight loss, and 200–300 min/week for weight maintenance. A weekly duration of 150 min is generally considered insufficient for fat loss in most obese individuals.[17]

The minimal weekly volume recommendation of the ACSM for health is 500 to 1000 MET-min/week. For weight loss, 1500 to 2000 MET-min/week or more is recommended.[17]

The ACSM recommends a three-stage progression for obesity:[17] *(i)* increasing duration, with gradual increase for example 10 min to 30, then 45, and 60 min; *(ii)* increasing frequency, from three days to five to seven days per week; *(iii)* increasing intensity, from 40% HRR to 50 to 60% HRR or more according to individual aerobic capacity. In obese individuals, gradual progression is essential to reduce injury and cardiovascular risks.[17]

Aerobic exercise types include walking, low-to-moderate-intensity running, swimming, and stationary cycling.[19,20] However, conventional land-based aerobic exercises (e.g., walking and running) may increase joint load in obese individuals, triggering knee, hip, and low back pain and reducing adherence. Conditions commonly accompanying obesity, such as OA, postural disorders, movement restriction, and musculoskeletal deformities, also hinder participation.[21] Therefore, alternative aerobic exercise modalities that reduce joint load are clinically important. It is emphasized that exercise must be individualized for obese individuals due to their joint load, mobility limitations, and comorbidities. Due to excessive body weight, activities that place excessive load on the knee/hip joints are not recommended for initial exercise regimens.[16]

Low-impact exercise techniques such as aquatic exercises, elliptical training, and arm ergometry are considered safe and effective alternatives because they significantly reduce joint loading while preserving cardiovascular and metabolic benefits.[22] Aquatic exercises, through the buoyancy of water, reduce load by 50 to 70% and provide pain control and facilitate exercise participation.[23] Arm ergometry is defined as a safe method for developing aerobic capacity in obese individuals, or in those with OA or neurological problems, who cannot tolerate lower-extremity loading.[24,25]

These recommendations should be adapted to different individuals in clinical practice. Exercise must be personalized by evaluating OA, diabetic neuropathy, cardiovascular risk, balance issues, and physical capacity. Applying FITT-VP principles is critically important for exercise safety and sustainability. For obese individuals with physical disabilities, low-impact activities such as aquatic exercise, stationary cycling, elliptical training, and arm ergometry are recommended.

Aquatic exercises

Aquatic exercise is a highly recommended method for obese individuals with musculoskeletal limitations. The buoyancy of water, sensory input from water temperature, hydrostatic pressure, and turbulence facilitates exercise performance.[2,3,26,27] Buoyancy reduces load-bearing stress on the knees, hips, and spine by 50 to 70% and decreases joint load. Aquatic therapy is beneficial for individuals with OA, chronic low back pain, or movement restriction.[26-28]

In the geriatric obese population, musculoskeletal disorders, cardiac or pulmonary diseases, peripheral vascular disease, and neurological impairments lead to attrition rates of 14 to 66% in land-based exercise programs. Under these conditions, aquatic exercise offers an important alternative. Studies have shown that aquatic therapy results in less pain and stiffness compared to land-based exercise.[26,29-31]

Primary benefits of aquatic exercise are reduced joint stress, decreased pain, increased cardiovascular fitness and caloric expenditure due to water resistance, improved balance and reduced fall risk through hydrostatic support, and higher adherence due to increased exercise enjoyment. Types of aquatic exercise are walking/jogging in waist- or chest-deep water, deep-water running (with a flotation belt), aqua aerobics (with foam dumbbells or paddles), resistance training using water resistance, stretching and flexibility exercises supported by buoyancy.

In a study conducted on obese female mice, the effects of two types of water-based exercise (aerobic and strength exercises) on body weight, adipose tissue, and metabolic indicators were investigated. One group of mice performed water-based strength exercises with weights attached to their tails (a load equal to 3 to 8% of body weight), while the other group performed 30 to 60 min of aerobic swimming (five days per week) without any added load. As a result, it was observed that in the group performing aerobic exercises in water, perirenal adipose tissue was reduced. Strength-based water exercises were also found to be beneficial, but aerobic water exercises were observed to be more effective.[28]

In a study evaluating the effects of aquatic exercise on functional limitations caused by chronic low back pain in obese women (BMI ≥27 kg/m^2), participants performed walking, running, cycling, and flexibility exercises in water for 12 weeks. As a result, a marked reduction in disability due to low back pain, significant improvement in pain severity, better activities of daily living, and better sleep quality were observed in individuals performing aquatic exercises. Exercise adherence was determined as 92%. Since the load placed on the spine during land-based exercise can be challenging for obese patients, and attrition rates are very high, aquatic exercise is recommended as a safe, low-risk, and effective rehabilitation method for women with coexisting low back pain and obesity.[29]

In a study in which aquatic exercise and land-based exercise were compared in patients with obesity-related knee OA, patients performed exercise three days per week for eight weeks in 40-min sessions. Aquatic exercise was performed by patients in a pool at 34°C and 115 cm depth, and walking, aqua-running, cycling, resisted arm and leg movements, and warm-up and cool-down periods were included. The land-based exercise group performed mobilization, stretching, and strengthening exercises for the same duration and intensity. While a significant reduction in body fat percentage was detected in the aquatic exercise group, no significant change in body fat was detected in the land-based exercise and control groups. Activity limitation due to pain significantly decreased in the aquatic exercise group.[30]

In obese patients, pain and movement limitation caused by knee OA can be safely reduced through aquatic exercise. The water environment reduces gravitational load and alleviates stress on the joint. Viscous resistance increases muscle strength, and the temperature and pressure of water support circulation and proprioception. Owing to these properties, aquatic exercise programs reduce pain while increasing exercise adherence.[30]

A study examining the effects of a single water-based exercise session on appetite and energy intake in adolescents diagnosed with obesity stated that aquatic exercise did not have a negative effect on energy balance and could, therefore, be safely included in weight control programs. This method may offer a more sustainable physical activity option by reducing joint strain.[31]

Moreover, in a study investigating the effects of aquatic exercise on body composition and metabolic syndrome components in older women with sarcopenic obesity, participants over 60 years of age performed aquatic exercises (resistance + aerobic) three days per week for 12 weeks, with a water temperature of 30°C, exercise intensity of Borg RPE 13-15 (moderate-intensity), and exercise duration of 45 min (7.5 min warm-up, 20 min resistance, 15 min aerobic, 7.5 min cool-down). Among body fat percentage measurements, leg fat percentage decreased significantly in the exercise group. The rate of sarcopenia did not change. According to the results of the study, aquatic exercise could be considered effective in reducing body fat in older women with sarcopenic obesity, with limited effect on increasing muscle mass. Land-based resistance training may be recommended in addition to aquatic exercise to increase muscle strength and functional capacity.[32]

Aquatic exercises are a safe and effective exercise method for older and overweight individuals. The water environment reduces joint load, facilitates balance, and provides strength gain through resistance. Improvements in blood pressure and body composition demonstrate the positive effects of hydrostatic pressure and the temperature of water on the circulatory system.[26,27,32,33]

Arm/leg ergometry

Arm ergometry (upper extremity cycling) provides an alternative for non-weight-bearing aerobic exercise for individuals who cannot perform lower extremity exercise due to obesity, OA, amputation, or SCI. The benefits of this method include increased cardiorespiratory fitness, development of functional strength required for activities of daily living, and positive metabolic effects.[24,25] Arm ergometry training protocols are generally applied at moderate intensity, in 20- to 40-min sessions, and three to five times per week.[34]

Leg ergometry (cycle ergometry) is another aerobic exercise method frequently preferred in obese individuals due to low joint load, adjustable workload, and safe cardiorespiratory activation.[34] In a study comparing arm and leg ergometry, it was found that leg ergometry produced a more intense physiological response with higher heart rate, VO_2max, and lactate production values. Arm ergometry was observed to provide lower lactate accumulation and a more positive emotional experience. Both exercise types met the criteria for HIIT (above 85% HRmax). Perceived exertion was found to be higher in women compared to men, which was likely related to lower muscle mass and VO_2max values. Arm ergometry provided less negative emotional response and similar exercise enjoyment.[34]

In obese patients with SCI, arm ergometry, wheelchair propulsion, or functional electric stimulation (FES)-assisted exercise regularly performed during aerobic exercise increases fat oxidation and improves insulin sensitivity. Nevertheless, energy expenditure is somewhat lower in upper extremity/arm ergometry compared to lower extremity ergometry. Similarly, upper extremity resistance exercises or FES-assisted resistance exercises promote muscle hypertrophy and increase basal metabolic rate, which produces positive long-term effects on energy balance in these patients. The stimulation of passive lower extremity muscles with FES increases energy expenditure and slows muscle atrophy by preserving circulation and muscle tone. In obese patients with SCI, combined programs (FES + resistance + aerobic) increase energy expenditure while preventing muscle atrophy.[35]

Two different exercise methods to reduce obesity and cardiometabolic risks that develop due to inactivity after SCI, arm cycling exercise (ACE) and FES-leg cycle ergometry (LCE), were compared, and the 16-week effects of these two methods on energy expenditure, cardiorespiratory capacity (VO_2peak), and body composition (fat/muscle ratio) were examined. Arm cycling exercise resulted in a marked increase in energy expenditure (+85%) and significant improvements in absolute and relative VO_2 peak (+21% and +22%, respectively), as well as exercise capacity (+19%). Posttraining VO_2 peak values were significantly higher in the ACE group compared to the FES-LCE group. Both interventions reduced body fat, with a 6% reduction in fat mass in the ACE group and a 5% decrease in fat percentage in the FES-LCE group. In contrast, bone mineral density was significantly better preserved in the

FES-LCE group. In conclusion, ACE appeared more effective in enhancing energy expenditure and cardiorespiratory fitness, whereas FES-LCE provided advantages in fat reduction and bone preservation. A combined approach may offer synergistic benefits in mitigating obesity, cardiometabolic risk, and musculoskeletal deterioration after SCI.[36]

Stationary cycling/elliptical cycling

Bikes and elliptical bikes are used for closed kinetic chain (CKC) exercises, which involve fixing the distal extremity (e.g., foot on the ground) and engaging multiple joints simultaneously. This leads to reduced shear stress on the knee, improved joint stability, and functional strength development. The coactivation of quadriceps and hamstrings enhances joint protection.[37,38]

An elliptical bike (i.e., elliptical trainer or cross trainer) is a piece of cardio equipment that imitates the operation of both cycling and running movements and exerts a lower load on joints. It is frequently preferred by individuals who have issues in their knees, hips, or lower back but wish to perform high cardio exercises.[17]

Obesity often comes with joint overload, particularly knee, hip, and ankle joints, reduced mobility, and comorbidities (e.g., cardiovascular disease and diabetes). High-impact exercises (running and jumping) can worsen joint pain or cause injury.[16,17]

In a study investigating the long-term effects of different types of physical activity on structural degeneration in the knee joint in obese individuals, the effects of high-impact (running, ball games, and racket sports) and low-impact (cycling, elliptical, and swimming) exercise on knee cartilage and meniscus changes over 48 months were compared using magnetic resonance imaging (MRI). The knee structure of patients was examined with 3T MRI and evaluated in terms of cartilage, meniscus, bone marrow edema, ligaments, and joint fluid using the Whole-Organ Magnetic Resonance Imaging Score. Accordingly, high-impact exercise, particularly racket sports, was observed to accelerate degeneration in the knee joint. Low-impact exercise (elliptical, swimming, and cycling) was reported to preserve cartilage integrity and could be recommended for painless weight loss. According to the results of the study, elliptical bike training was identified as the safest and most joint-protective option for obese individuals.[39] The elliptical bike provides a low-impact, weight-supported, yet full-body aerobic option.

In a pilot study evaluating the effectiveness of combining resistance-controlled, HIIT, FES cycling exercises with nutritional counseling to reduce obesity developing after SCI, patients performed the exercises for eight weeks, three times per week, 30 min per session, with 30-sec high-intensity (80% maximum resistance) + 30-sec low-intensity intervals, while quadriceps, hamstring, and gluteal muscles were stimulated with surface electrodes. Exercise intensity was determined based on resistance levels instead of heart rate, as heart rate is not reliable in lesions at T6 and above. The FES cycling exercises were observed to reduce body fat percentage, increase leg muscle mass, and show a tendency to improve glycemic control in obese individuals after SCI.[40]

A 12-week heart rate-guided aerobic cycling program added to rehabilitation significantly reduced free fatty acid levels and obesity-related anthropometric measures in male patients with chronic stroke. These findings support cycling aerobic exercise as a safe and effective strategy to improve metabolic risk profiles in stroke survivors.[41]

Resistance exercises

Resistance exercise in obese individuals with physical limitations is critically important for improving general health outcomes, preserving lean body mass, and increasing functional capacity.[42] Conditions such as aging, sarcopenia, OA, and SCI require the customization of the exercise regimen.[42-44]

Obesity is not only characterized by increased fat mass but also frequently accompanied by sarcopenia and reduced muscle quality.[32] Resistance exercises increase muscle mass, muscle strength, and neuromuscular function, and they raise basal metabolic rate and provide significant improvements in glucose metabolism, insulin sensitivity, and functional capacity.[43]

Physical limitations in obese individuals (OA, SCI, musculoskeletal pain, movement restriction, sarcopenia, and low cardiorespiratory capacity) make resistance exercises challenging.[43,44] However, resistance training performed with appropriate modifications increases muscle mass, raises metabolic rate, improves insulin sensitivity, reduces fall risk, and enhances quality of life.[17,41,43] Physical limitations reduce participation rates in exercise programs among obese individuals by up to 40 to 70%. Resistance exercise has become a fundamental component of rehabilitation by improving muscle strength and functionality in addition to aerobic capacity.[17,42,44]

Resistance exercises increase muscle protein synthesis and stimulate the hypertrophy of type 2 fibers. Each increase in muscle mass raises resting energy expenditure and contributes to the sustainability of fat mass loss. Therefore, resistance exercises in obesity should be considered not only an aesthetic and functional intervention but also a metabolic treatment tool.[43]

In comparison to programs applying only aerobic exercises with an energy-restricted diet, adding resistance exercises reduces lean tissue loss, preserves fat mass reduction, and makes total weight loss more qualitative. In the sarcopenic obesity phenotype, resistance exercises raise lower extremity muscle strength and reduce fall risk and frailty.[45,46]

Among exercise approaches, open kinetic chain and CKC exercises are included, and CKC exercises stand out since they mimic functional movements, distribute joint loading more evenly, and increase muscle co-activation.[37] In CKC exercises, the distal segment (e.g., the foot) is fixed, and the movement involves the coordinated activity of multiple joints.

Recommended resistance exercise for obese individuals with OA are seated leg press (light-moderate resistance), mini-squat (low knee flexion angle), step-up (low platform), glute bridge/hip thrust, and knee abduction with TheraBand. Movements to avoid include deep squat, repeated jump/plyometric, and valgus-varus positions that cause pain. In OA patients, resistance exercises increase strength by 15 to 40%.[44,45]

The recommended approach in sarcopenic obesity is low load (20 to 30% one-repetition maximum) and high repetition (15 to 20 repetitions). Transition to the eight to 12 repetition range should be achieved through progressive overload from a slow, controlled eccentric phase. The most appropriate exercises in sarcopenic obesity include leg extension (pain-free range of motion [ROM]), chest press (machine), seated row, and deadlift modifications (trap bar, kettlebell). Twelve weeks of resistance training in sarcopenic obesity can increase muscle mass by up to 8%.[8,46]

Some modified resistance exercises for obese individuals with mobility and balance limitations may be listed as seated dumbbell exercises, CKC exercises on a stable surface, seated calf raise, and standing TheraBand row. Examples of additional exercises to improve balance include mini-squat, single-leg supported closed-chain activities, and step stabilization drills.[46,47]

In obesity, increased abdominal fat creates an anterior tilt, leading to lumbar loading and a pain cycle. Resistance exercises break this cycle. Recommended core-centered resistance exercises for obese individuals with low back pain include pelvic tilt, dead bug, bird-dog, modified plank (knee-supported), and gluteus medius strengthening (side-lying TheraBand).[46-48]

Flexibility and balance exercises

Obesity is not limited to increased fat mass. It is a multidisciplinary syndrome that affects musculoskeletal biomechanics, postural stability, proprioceptive sensation, and flexibility capacity. Increased body weight disrupts joint biomechanics, makes load distribution asymmetric, and leads to significant negative effects on both static and dynamic balance control. Therefore, in addition to aerobic and resistance exercises, flexibility and balance exercises are considered important treatment strategies targeting the functional and neuromuscular components of obesity.[49]

Obesity leads to changes such as increased tension in the joint capsule, soft tissue shortening, reduced viscoelasticity in the fascia and muscle-tendon unit, and mechanical limitation of joint ROM by subcutaneous adipose tissue, particularly in load-bearing joints such as the knee, hip, and lumbar spine. This is associated with range-of-motion losses, particularly in hip flexion, knee flexion, spinal mobility, and shoulder abduction.[46,50,51]

In obese individuals, neurosensory adaptations such as reduced sensitivity of ankle and knee mechanoreceptors, decreased nerve conduction and afferent feedback due to excess adipose tissue, delayed motor unit recruitment and loss of coordination, and altered activation patterns in cortical motor areas are observed. These result in increased postural sway and elevated fall risk.[51]

In the obese population, postural abnormalities such as increased lumbar lordosis, anterior pelvic tilt, genu valgus, pes planus, and forward displacement of the body's center of mass are frequently observed. These changes lead to compensatory muscle shortening along the kinetic chain, inhibition in antagonistic muscles, and loss of flexibility.[46]

Flexibility exercises increase the stretch tolerance of the muscle-tendon unit, elastic recoil capacity, fascial gliding, and joint capsule mobility. In obese individuals, shortening is more pronounced, particularly in the hamstrings, gastrocnemius-soleus, iliopsoas, pectoral muscles, and lumbar paraspinal muscles. At the same time, increased ROM provides relief in functional activities (sit-to-stand, bending, walking), improves biomechanical load distribution, increases exercise participation capacity, and reduces pain levels.[52]

The safest and most commonly used method in obese individuals is static stretching. A duration of 20 to 30 sec, repeated two to four times, with a painless mild-moderate stretch sensation, is considered the safest method. Recommended stretching regions in obese patients include hamstring, quadriceps (side-lying position), hip flexor (modified Thomas stretch), calf (gastrocnemius-soleus), trunk lateral flexion, and pectoral stretch (doorway).[51,52] High-velocity movements should be avoided in advanced OA cases. Proprioceptive neuromuscular facilitation (hold-relax/contract-relax) stretching can produce significant ROM increases but should be cautiously applied in some obese individuals due to accompanying pain or weakness.[49] These techniques are used to achieve neuromuscular inhibition through isometric activation. Aquatic flexibility exercises in obese individuals reduce joint load by 50 to 70%. They are particularly suitable for those with OA, low back pain, or obesity grade ≥3. Examples include poolside hamstring/calf stretching, water-based trunk rotations, and aqua-yoga stretching movements.[26,27]

For obese individuals with knee OA, hamstring-quadriceps imbalance should be reduced, and hip abductor/rotator flexibility should be increased. Excessive flexion should be avoided in knee OA cases. Static stretching should be preferred, and painful end ranges should be avoided. Examples include hamstring supine stretch, calf wall stretch, and hip flexor kneeling stretch (padded).[49,50]

In obese patients with low back pain and lumbar limitation, lumbopelvic muscle imbalance (tight hip flexor causing anterior pelvic tilt) should be reduced. Supine hamstring stretch is safer in low back pain cases. Recommended stretches for these patients include cat-cow, modified child's pose, piriformis stretch, and posterior chain stretching.[49]

In individuals with severely limited mobility and morbid obesity, basic positioning at the chair or bedside, passive stretching supported by TheraBand, seated lateral flexion, and seated forward-leaning hamstring stretch methods can be used.[50]

Obese individuals with balance problems may begin with a stable surface, wall-supported stretching, low-risk stretching with one foot placed on a step, and seated calf + ankle mobility stretches.[52]

In comparison to normal-weight individuals, obese individuals exhibit findings such as increased anteroposterior and mediolateral postural sway, delayed balance reactions, and weak ankle-hip strategies. Balance training provides functional improvement by the strengthening of proprioceptive sensation, increased motor unit synchronization, strengthening of the ankle strategy, increased muscle spindle sensitivity, and acceleration of somatosensory integration.[51]

In obese adults, fall risk increases to two to three times that of the normal-weight population. With balance exercises, walking speed increases, gait variability decreases, reactive balance responses strengthen, and the load distribution that is impaired due to knee and hip OA is stabilized.[52]

In severe knee/hip OA cases, working on excessively unstable surfaces is contraindicated. In the presence of diabetic neuropathy, the program should not be initiated without evaluating proprioceptive loss. In morbidly obese patients (BMI >45) modification is required. Cautious progression is necessary in cases of dizziness, orthostatic hypotension, and severe vestibular disorders.[53]

Flexibility and balance exercises in obese individuals with physical limitations increase mobility, reduce pain, improve posture, and increase participation capacity in resistance/aerobic exercises. Programs modified according to accompanying conditions, such as OA, low back pain, sarcopenic obesity, and balance problems, significantly improve the functional capacity of patients.[51]

In conclusion, exercise interventions not only support weight loss but also increase cardiovascular fitness, improve mobility and functional capacity, preserve lean body mass, and improve psychological well-being. Since individuals with physical disability are prone to obesity due to immobilization, it is essential that methods to increase physical activity be applied to these patients. The rate of progression must be carefully adjusted based on both the neurological condition and the limitations associated with obesity. In obese individuals, in addition to cardiovascular and pulmonary demand assessments before exercise, musculoskeletal limitations must be considered when planning exercise, and long-term exercise programs that can be performed while protecting joint health must be recommended. The most effective model in obese patients with physical limitations is a multimodal exercise approach. Such an approach should include ensuring low joint load (aquatic exercise, arm ergometry, and elliptical cycling) and, if possible, a resistance component to improve body composition (fat loss and muscle mass increase), as well as flexibility and balance exercises.

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