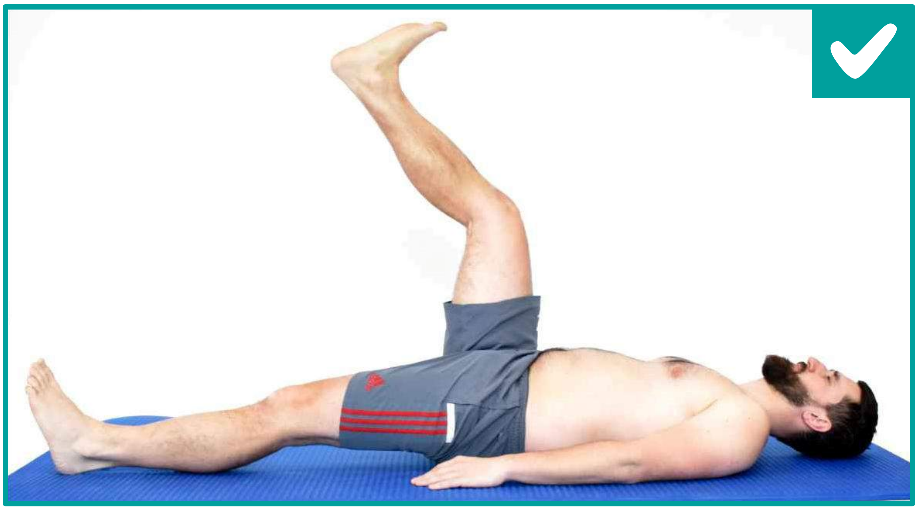


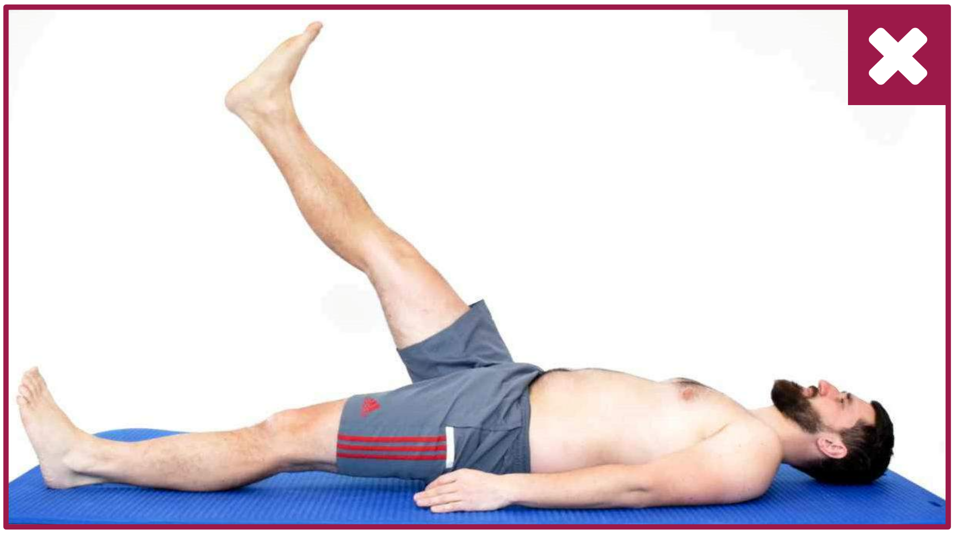


**Figure** 4 Stretching the back of the lower limbs

**Stretching and activation of hip joint internal and external rotators**

The weight is primarily on the front leg. The sole of the front foot should be fully grounded. With a straight back, rotate the entire torso and rear leg around the hip of the front leg (in the illustration, the right hip) — the rear leg pivots on the toes. During forward pelvic rotation, you should feel a stretch in the gluteal muscles on the right side. During backward rotation, you should feel a stretch on the inner side of the right thigh. The torso remains upright without tilting to either side. Imagine the pelvis and torso rotating above the right hip as if on a pivot. Hold each end position, i.e., the phase of maximum forward and backward rotation, for at least 5 seconds, preferably 10. Repeat the forward and backward rotations 3–5 times, then switch legs.

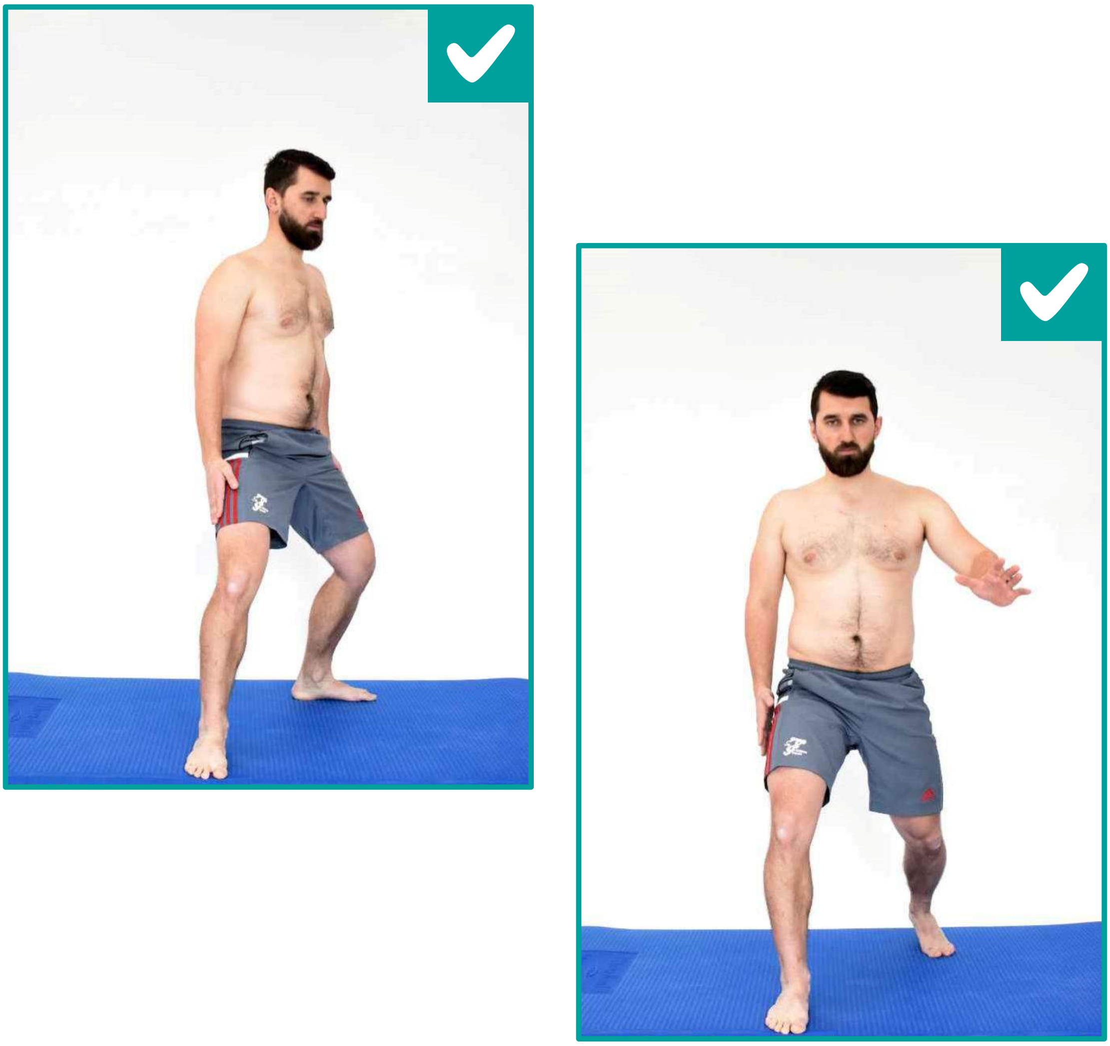


**Figure 5** Stretching and activation of hip joint internal and external rotators

An error occurs if the lumbar spine arches excessively during rotation, the front knee moves side to side, or the sole of the front foot is not fully grounded.

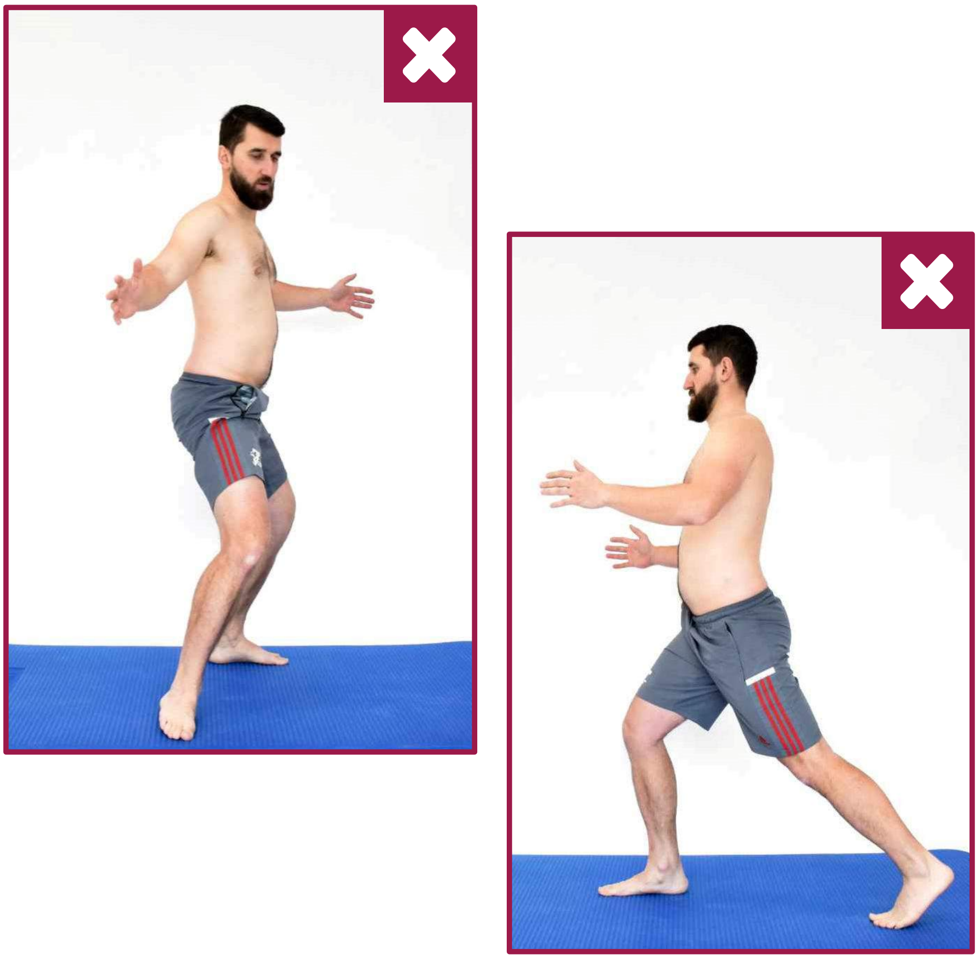


**Figure 6** Errors of stretching and activation of hip joint internal and external rotators

**Cycling**

Cycling or using a stationary bike is another suitable activity (14). The movement is simple and controlled, without jolts or abrupt changes in direction. It is well tolerated even by individuals with degenerative changes, injuries, or postsurgical recovery who need to regain muscle strength. If you choose a suitable route without steep hills or an appropriate program on a stationary bike, cycling can also be suitable for individuals with various cardiovascular or respiratory conditions. During cycling, try to breathe through your nose with your mouth gently closed if the intensity allows. The sole of your foot should be positioned on the pedal so that the ball of the foot, not the toes, bears the weight. Adjust the saddle so the leg remains slightly bent at the knee (approximately 20 degrees) when the pedal is at the bottom and is flat. To avoid improper extension of the cervical spine and excessive hip flexion, commonly strained areas in cyclists, it is advisable to have the handlebars higher and closer to the saddle (a shorter and raised stem). While this is less aerodynamic, it allows the spine to stay upright, which prevents back and hip pain. The pedaling cadence should be at least 60 revolutions per minute (60–90).

Cycling is highly recommended, but since it is performed in a seated position—a posture much of the population spends most of their day in—it is essential to compensate for this position appropriately. Focus on stretching the hips, improving thoracic mobility, and loosening the shoulders. If you have any medical conditions or musculoskeletal issues, it is always advisable to consult a specialist. Before cycling (or using a stationary bike), gradual warm-ups and exercises targeting specific body areas are essential. Perform exercises slowly, in a controlled manner, without excessive force. Hold each exercise for 10 seconds and repeat 3–5 times. Never exercise through pain. During workouts, you may feel stretching, muscle activity, and loading of the body's support segments, but no pain.

**Exercise on all fours: arching and stretching**

In this exercise, arch your back as much as possible, then try to straighten your chest area downward and forward while stretching your arms out in front of you. You should feel pressure and stretching between the shoulder blades, stretching around the shoulders, and stretching of the chest muscles. Stretch your back into a "plank" position, feeling the spine straighten. Extend your head forward. The lumbar and cervical spine should not arch, and the head should not tilt back.

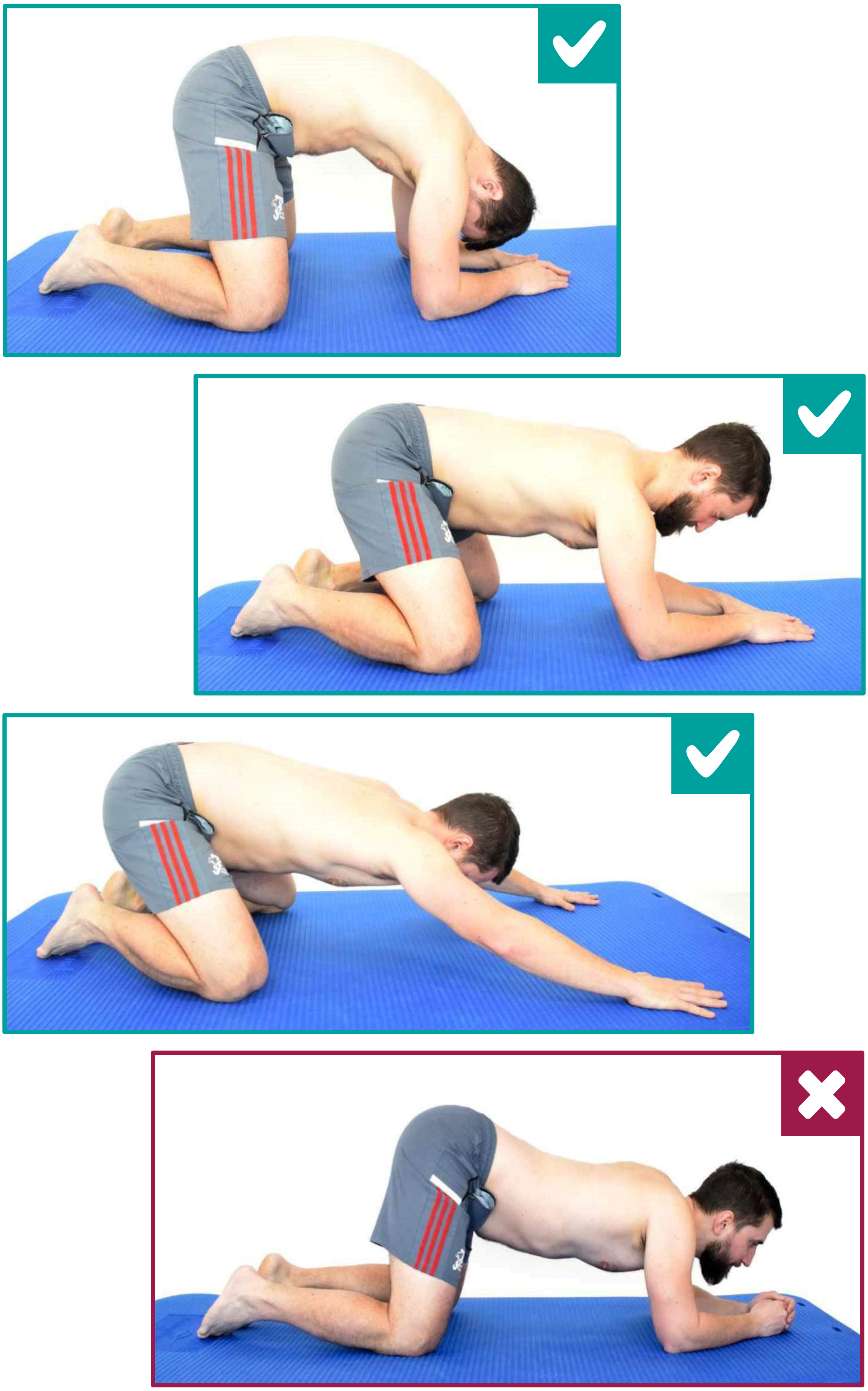


**Figure 7** Exercise on all fours: arching and stretching

**Exercise in all-four position: forward rocking**

From the all-fours position, shift your pelvis and torso forward until your spine and thighs form a straight line. You should feel abdominal muscle activation and a stretch around the groin area. Support yourself on your entire palms and all fingers pointing forward, pressing your hands into the surface. Hold the final position for at least 5 seconds, preferably 10, and breathe deeply into your chest and abdomen as if expanding a stretchable band wrapped around your torso in all directions (360 degrees). Direct your breath into the "lower abdomen," above the groin, as well as backward and to the sides, into the area of the lower ribs. Avoid arching your lower back or tilting your head backward during the exercise.

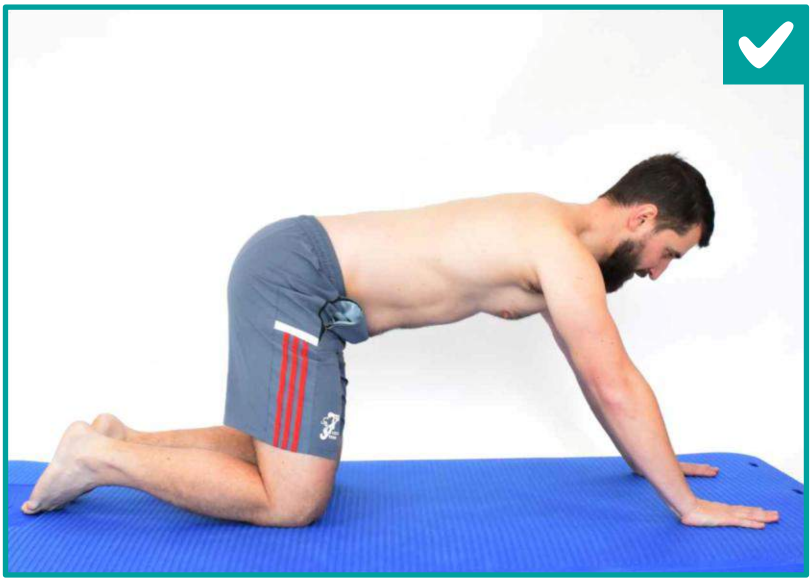


**Figure 8** Exercise on all fours

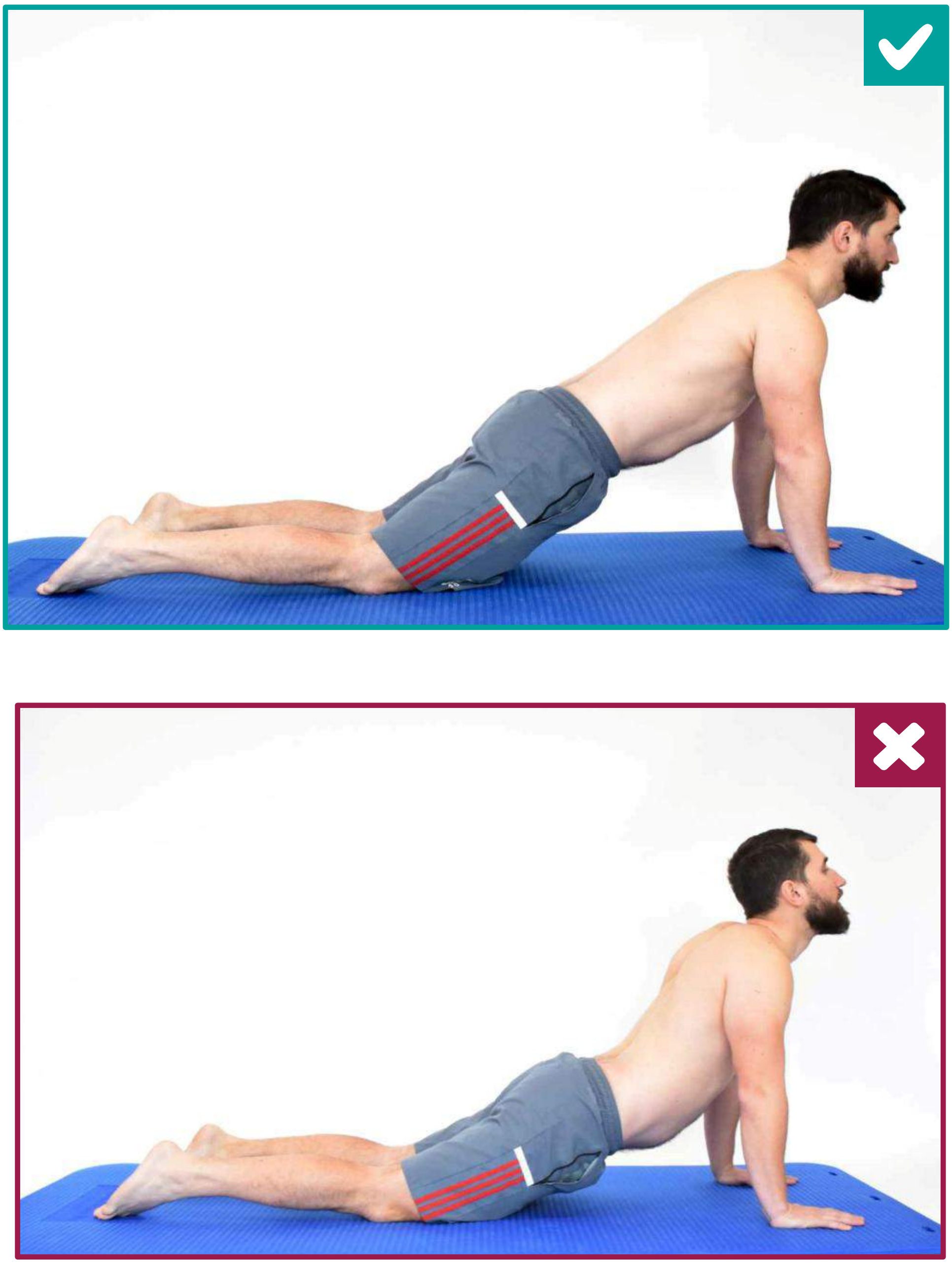


**Figure 9** Exercise in all-four position: forward rocking

**Oblique sitting**

Support yourself on the outer side of your thigh and glute (in the illustration, the right lower limb) and on your hand (right hand), positioned in line with the supporting hip joint. During this exercise, try to rotate your torso forward as much as possible until you are also supported by your other hand. Lengthen your neck, pulling your head away from your shoulders. Keep your back straight in the initial position and throughout the entire phase of trunk rotation. Draw your shoulders down away from your ears. Actively press the front knee into the surface. You should feel pressure and stretch in the thoracic spine and the gluteal area of the supporting (right) leg. In the final position, with support on both hands, hold for 5–10 seconds, then slowly and in a controlled manner, return to the starting position. Repeat the exercise 3–5 times, then switch sides.

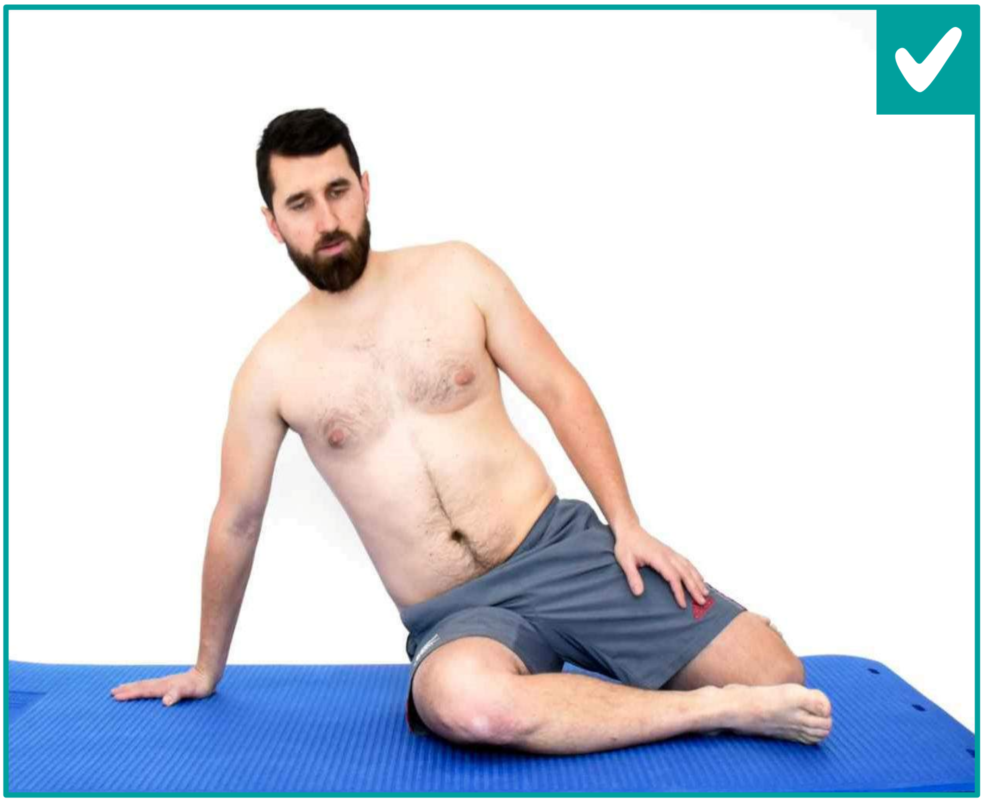


**Figure 10** Oblique sitting

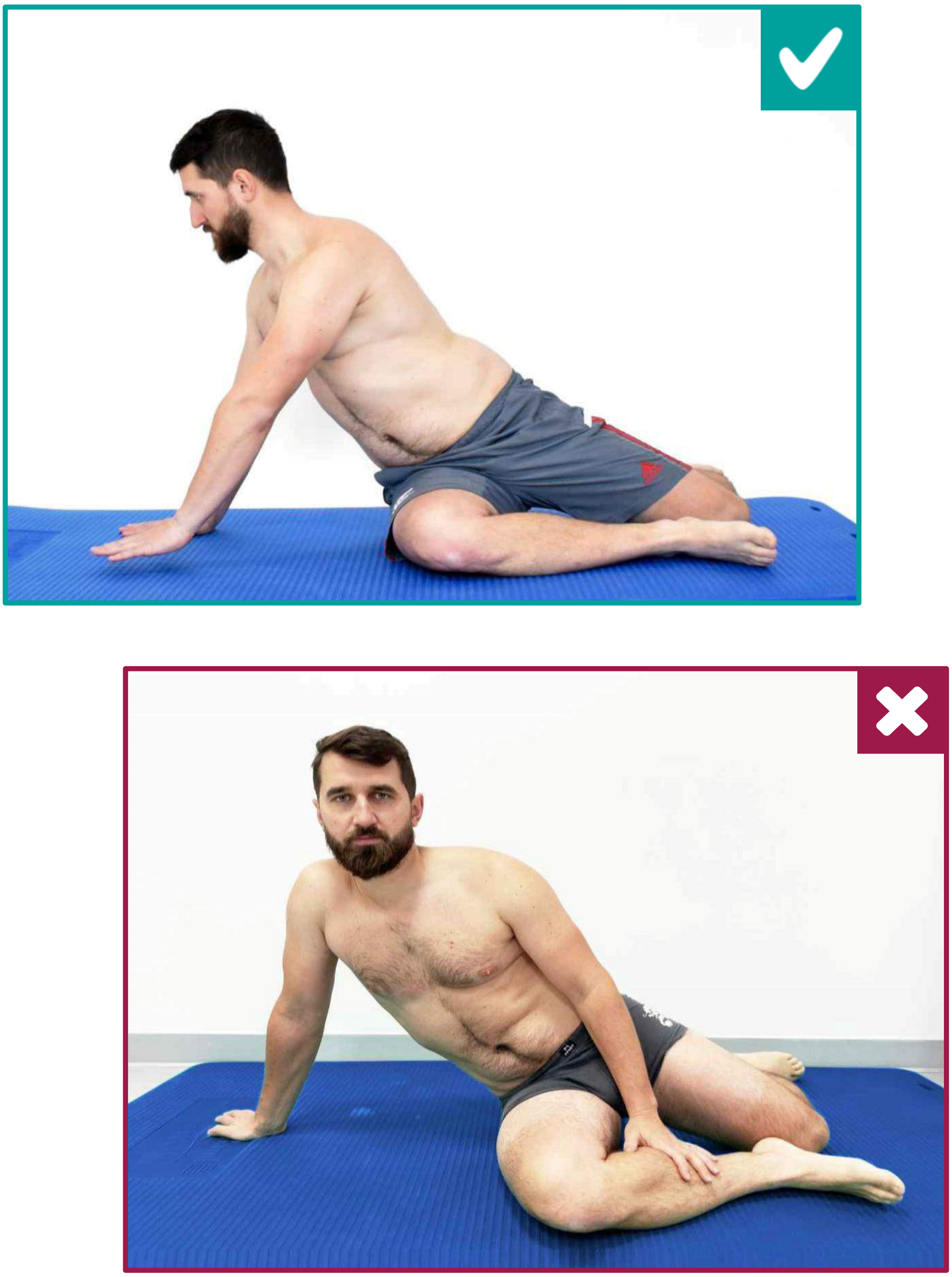


**Figure 11** Errors of oblique sitting

**Bear position**

In the bear position, aim to straighten your thoracic spine and align the entire spine. Extend your head away from your shoulders and alternately extend each leg backward as far as possible toward the ceiling. Keep your back straight throughout the movement. You should feel pressure around the thoracic spine, a stretch in the groin of the extending leg, and activation of the abdomen, glutes, and upper limbs bilaterally. Support yourself with your entire palms and fingers pointing forward. Draw your shoulders down away from your ears. Breathe deeply into your chest and abdomen. While extending your leg, be mindful not to tilt your entire body to the side. Your back must remain straight, "like a plank," throughout the exercise.

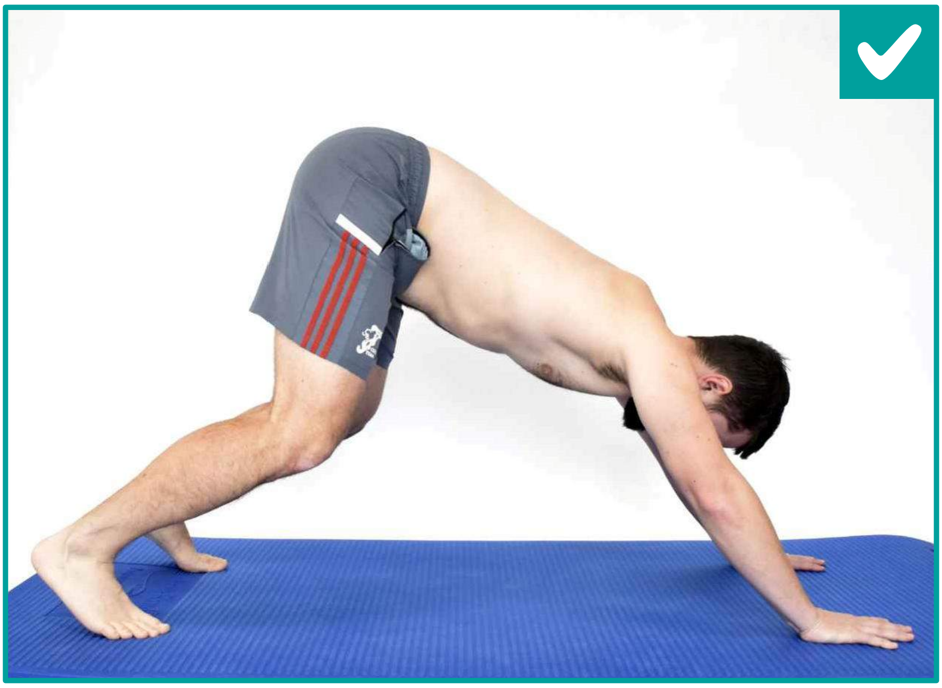
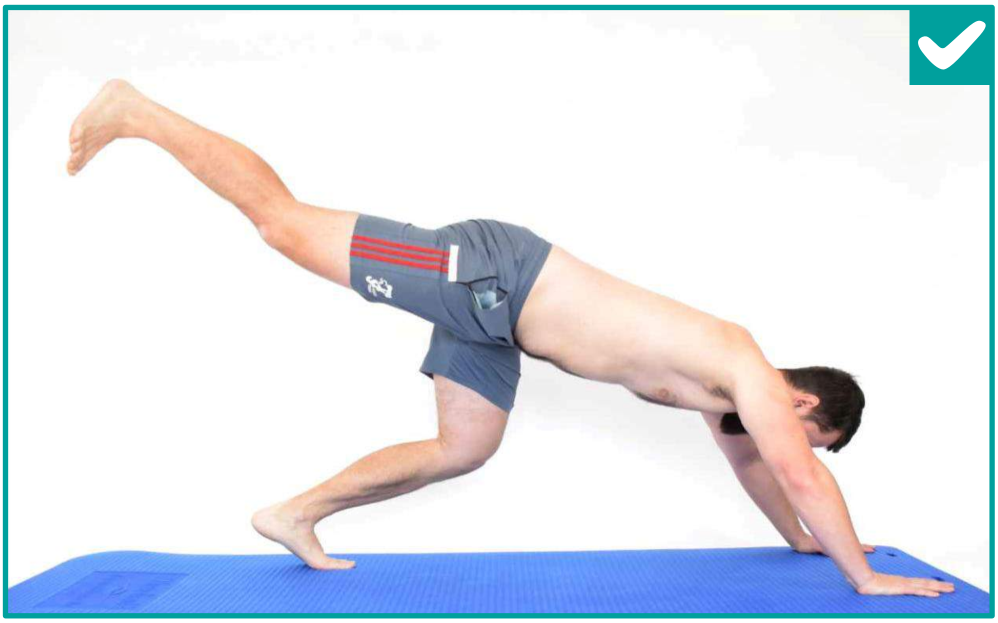


**Figure 12** Bear exercise



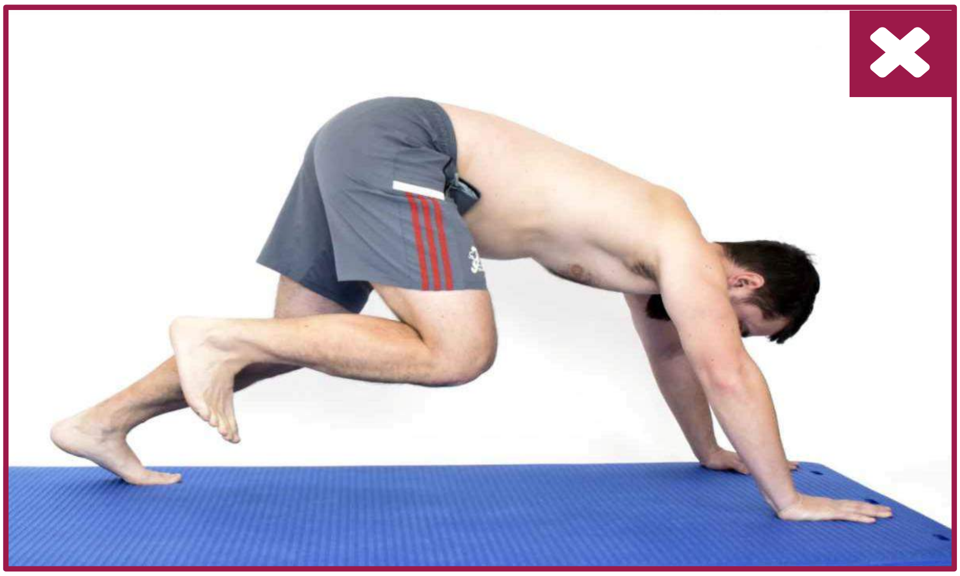


**Figure 13** Errors of bear exercise

**Hang**

The hang is a suitable compensatory activity. It stretches the entire spine and provides decompression. A supported hang using the lower limbs is easier. Grab a sturdy bar with your hands and hang downward into a deep squat. The soles of your feet should be fully grounded. Draw your shoulders downward and keep your shoulder blades wide and flat against your ribcage (not protruding). Extend your head away from your shoulders as if preparing to do a pull-up. Breathe proportionally into your lower ribcage and abdomen (360 degrees).

If you have sufficient strength and mobility in your shoulder joints, you can perform a hang without leg support while adhering to the same principles.

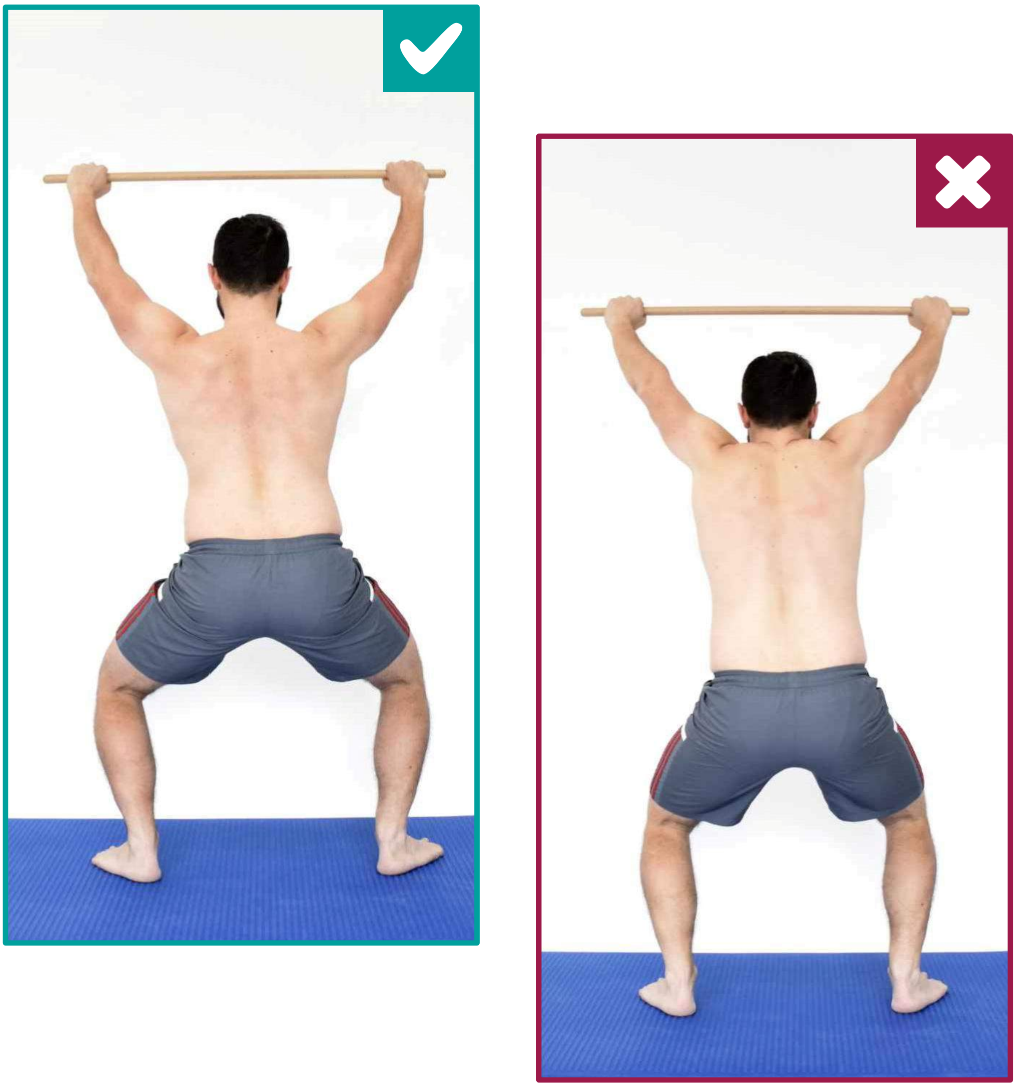


**Figure 14** Proper technique

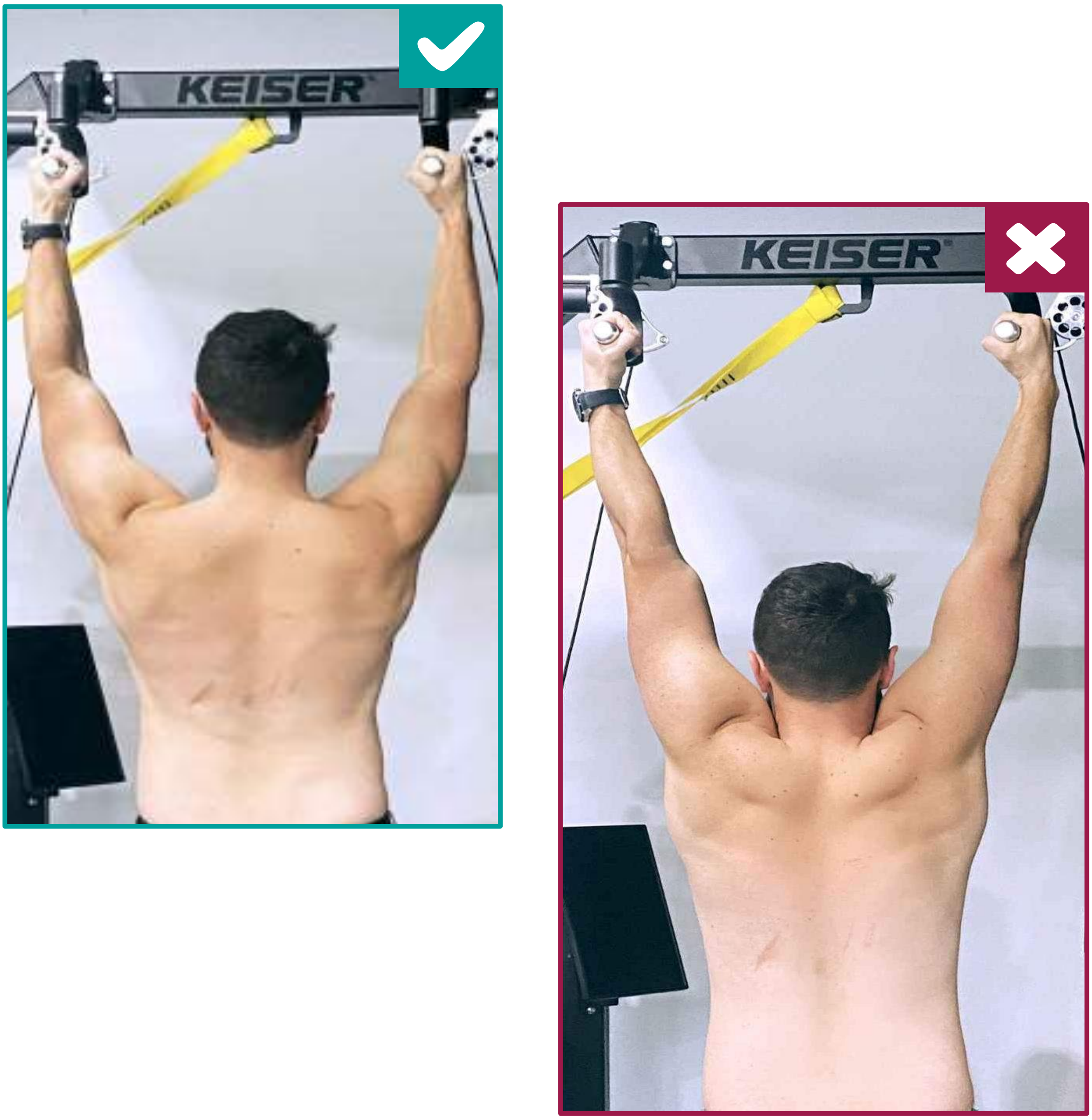



**Figure 15** Hang exercises

**Cycling posture**

While cycling, extend your head away from your shoulders to align it with your spine. Avoid tilting your head backward. Pressing into the handlebars, draw your shoulders away from your ears, and keep your back straight or slightly and smoothly curved. During the ride, the pelvis and torso should not sway excessively from side to side. Keep your shoulders and neck relaxed, and direct your breath into your abdomen and lower ribcage.

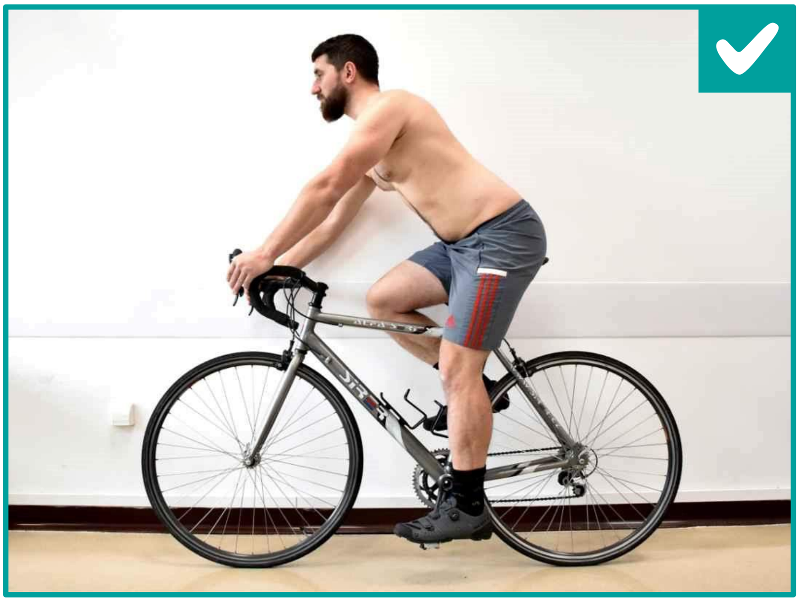


**Figure 16** Cycling

**Swimming**

Swimming is a physical activity that engages the entire body while being buoyant in water. It eliminates impact, making it joint-friendly and suitable after injuries or for individuals with degenerative changes in the musculoskeletal system. However, swimming can be demanding regarding range of motion, particularly in the hip and shoulder joints. The breaststroke style requires good hip joint mobility, while freestyle and backstroke demand sufficient mobility in the shoulder joints. The breaststroke technique can easily strain the cervical and lumbar spine areas. Alternating styles is recommended. As with any physical activity, proper preparation for swimming is important to mitigate potential negative impacts. Focus mainly on thoracic, hip, and shoulder mobility. Patients with any medical conditions or musculoskeletal issues should always consult a specialist. Preparation should include gradual warmups and exercises targeting specific body parts. Perform the exercises slowly and in a controlled manner. Repeat each exercise 3–5 times, holding the position for 5–10 seconds. You should feel stretching, pressure, or muscle activation during the exercises but no pain.

**Exercise in a prone position**

Support yourself on your forearms and the pubic area. Extend your head forward and away, keeping your neck neutral without tilting it backward. Raise your head just enough to align it with your spine. Rest on your pelvis (pubic bone), not your navel. Direct your breath proportionally into your abdomen and lower ribcage and draw your shoulders away from your ears. Avoid excessive arching in the lower back and cervical spine. Instead, aim to straighten the thoracic region, activating the muscles between the shoulder blades and the abdominal muscles.

**Figure 17** Exercise in prone position

**Exercise in the supine position**

Lie on your back without arching your lower back. Your spine should remain in contact with the surface but not press forcefully into it. Bend your hips and knees to approximately a 90-degree angle. Raise your arms as far as possible overhead without arching your back or losing contact with the surface. Draw your shoulders away from your ears. You should feel a stretch in your shoulders, chest muscles, and thoracic spine while engaging your abdominal muscles.

**Figure 18** Exercise in supine position

**High ½ kneeling**

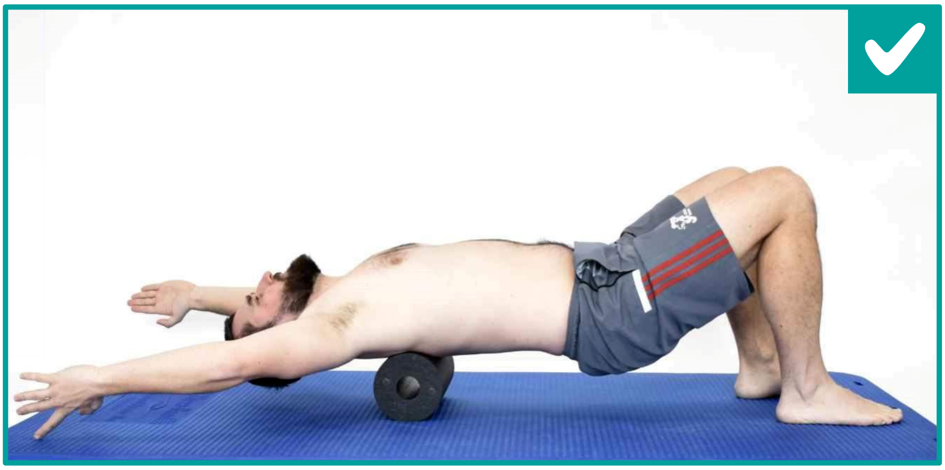
In this position, distribute your weight evenly on both legs. Push your pelvis forward while raising your arms overhead. Extend your head away from your shoulders without tilting it backward. Focus on pushing the groin of the kneeling leg forward, not the navel. Avoid arching your lower back; keep your spine straight. You should feel a stretch in the groin of the kneeling leg, shoulder joints, and chest muscles. Hold the position for 5–10 seconds, then relax. Repeat the exercise at least two more times. Afterward, switch legs and perform the same exercise with support on the opposite knee and leg

**Figure 19** High ½ kneeling

**Figure 20** High ½ kneeling incorrect movement technique

**Thoracic spine mobilization**

For thoracic spine mobilization, you can use a foam roller. Place it under the mid-thoracic spine and symmetrically support yourself with both soles flat on the ground. Keep your pelvis lifted above the surface. Hold this position for a few seconds, then slightly move the roller up or down, gradually stretching the entire thoracic spine. Focus on ensuring the extension comes from the thoracic spine, not the lumbar spine. Keep your abdominal muscles engaged and your pelvis elevated throughout the exercise to achieve this. You should feel a stretch or pressure in the chest area and a stretch around the shoulders and chest muscles.



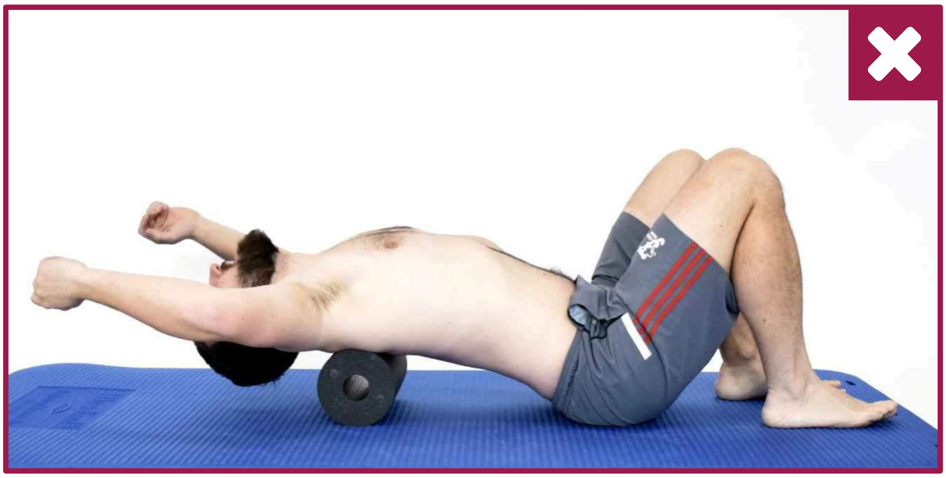


**Figure 21** Thoracic spine mobilization

**Functional capacity**

During sports activities, we sometimes exceed our functional threshold, a state in which we can no longer maintain an ideal posture and quality of movement, and our joints lose optimal muscular control. Poor postural control can cause pain and dysfunction in the musculoskeletal system, leading to the situation where "the more we exercise, the more it hurts."

When the muscular system, guided by the central nervous system, fails to keep the joints in optimal positions under load, repetitive improper movement can overburden passive structures such as ligaments, discs, cartilage, menisci, and other tissues, leading to irreversible degenerative changes. Training for optimal motor control is crucial for maintaining the longevity of the musculoskeletal system (15–17). It is not just about how much we exercise but also about the quality of exercise—whether we can control our movements, identify errors, and correct them ourselves. Warm-ups or specific preparations for a particular sport are designed for this purpose. Above, we provide examples of suitable exercises before walking, running, cycling, and swimming. Similarly, customized exercise routines can be created for other types of physical activities. Maintaining ideal muscle function during sports is much more challenging, as muscles must facilitate movement and protect the joints through balanced activity. Sports often demand maximum range of motion, speed, strength, or endurance.

When demands become too high, we exceed our functional threshold and adopt suboptimal stabilization strategies. Some muscles become overactive, others underactive, and joints move into positions where they are overburdened. Each individual has a unique functional capacity zone, where movement quality is sufficient and the risk of overload or injury is low. Above the functional capacity zone is the overload zone, where movements can still be performed but with poor quality, risking degenerative changes and making injuries more likely. Beyond the overload zone lies the threshold of absolute exhaustion, at which point the body can no longer perform the movement and must stop the activity. Functional capacity varies significantly between individuals. A trained athlete has different abilities than someone who trains recreationally or has not exercised for a long time. Three main factors push us beyond our functional capacity during sports: excessive demands on strength, endurance, and speed. In professional sports, athletes often exceed their functional threshold to achieve maximum performance "at all costs." However, during rehabilitation or training for the general population, this should be avoided or minimized. It is crucial to recognize the moment when movement quality begins to fail. At that point, we should stop, rest, correct errors, and resume with total control. Regular physical activity improves control over time, enabling us to exercise longer and more effectively. The musculoskeletal system positively adapts to the activity, expanding our functional capacity zone.

Control of movement requires full awareness. Therefore, focusing entirely on the movement and eliminating distractions, such as listening to music, spoken word, or watching videos while exercising, is essential, especially in the beginning. Activities like listening to audiobooks or watching movies during exercise should only be done once the movement becomes sufficiently automated.

It is always advisable to consult a professional (e.g., a sports coach or physiotherapist) to identify significant errors, learn to recognize them and correct them effectively.

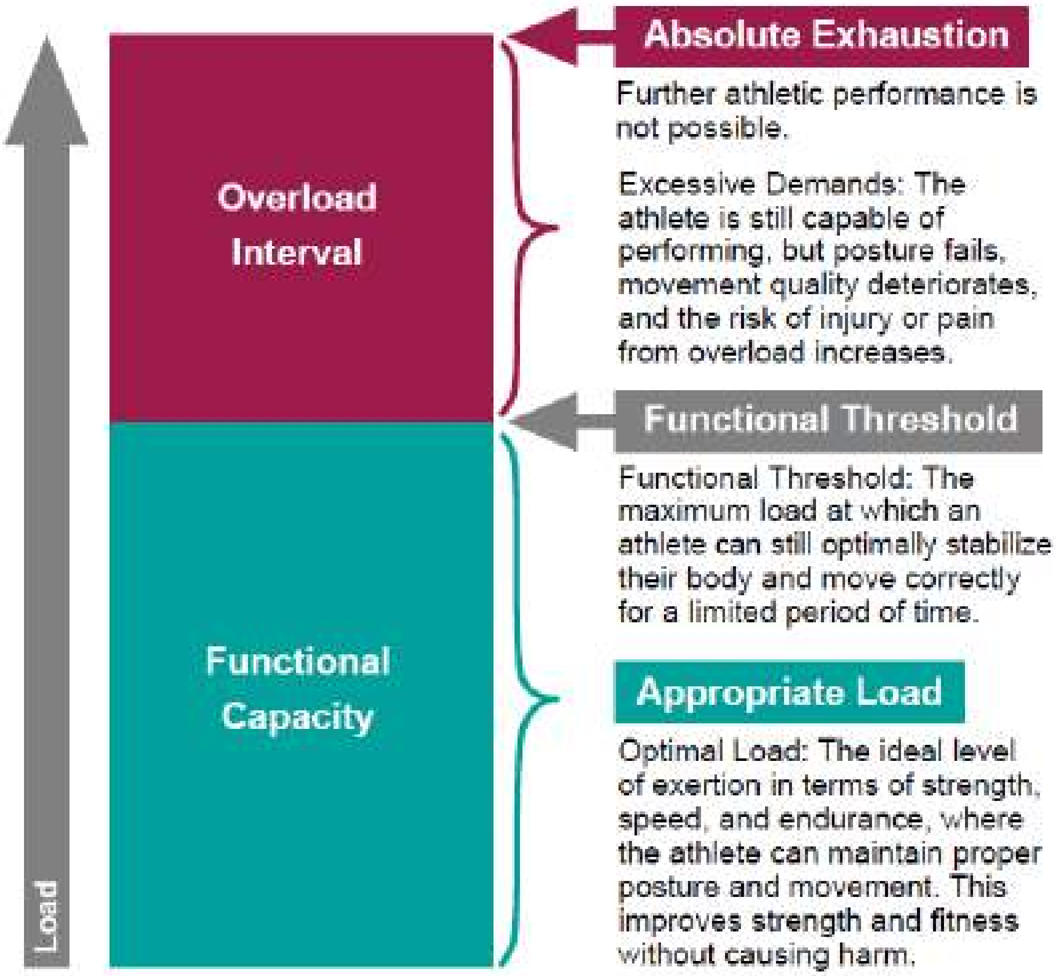



**Figure 22** Loading and functional capacity

**We quickly reach the functional threshold.**

**When the functional threshold is exceeded, we lose quality.**


**Figure 23** Functional threshold and quality of exercise

**Increasing the functional threshold the goal of regular training**

Training focused on increasing functional capacity is essential for injury prevention and maintaining performance.

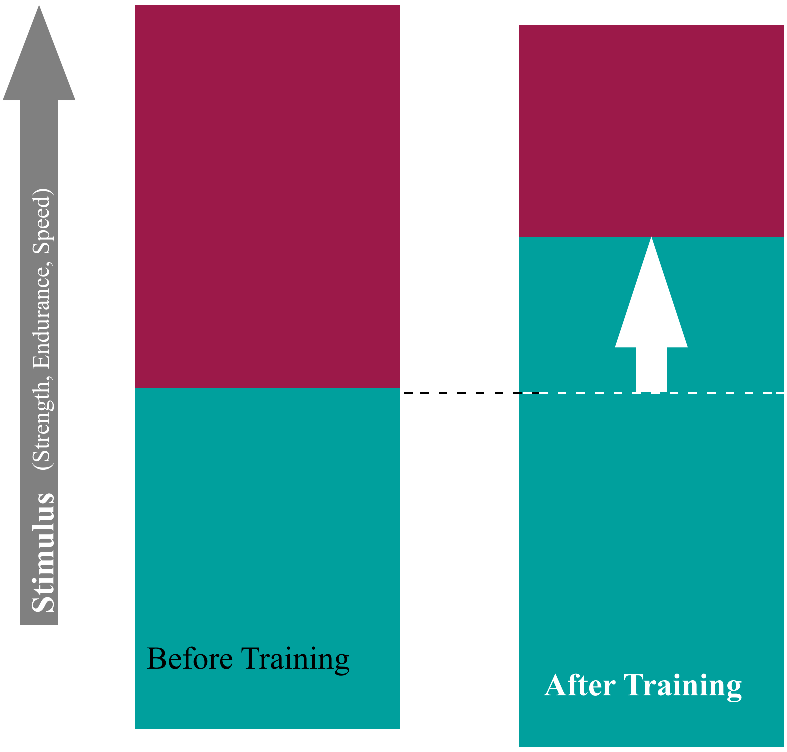



**Figure 24** Increasing functional capacity

Increasing the functional threshold means the athlete must train in the functional threshold zone, stimulating the movement system to adapt. This will allow the athlete to move correctly even under higher loads.

The exercises mentioned above serve as preparation for selected physical activities. A proper warm-up also helps to increase the functional threshold, improve and enhance athletic performance, and reduce the risk of overuse and injury. Especially after the COVID-19 pandemic, when a portion of the population experienced decreased physical activity and increased hypomobility, it is important to emphasize proper body preparation for movement to minimize the risks associated with returning to an active lifestyle (18–20).

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## Chapter 8

## Enhancing physical activity and postural health: lessons from the COVIDMOVE project

### Introduction

Hypoactivity, often referred to as physical inactivity or sedentary behavior, is defined as a lack of sufficient physical movement required to maintain optimal health. It is characterized by prolonged periods of minimal energy expenditure, such as sitting, lying down, or engaging in passive activities, without incorporating adequate moderate-to-vigorous physical exercise into daily life. According to the World Health Organization (WHO), adults should engage in at least 150–300 minutes of moderate-intensity aerobic activity or 75-150 minutes of vigorous-intensity aerobic activity per week (1) to mitigate the risks associated with hypoactivity, yet a significant portion of the global population fails to meet these guidelines. García-Hermoso et al. report that only 17–20% of adults and adolescents meet the WHO guidelines for both aerobic and muscle-strengthening activities (2). Factors associated with low physical activity include female sex, older age, higher education and wealth, unemployment, and urban settings (3) This lack of adherence to physical activity guidelines increases with age, particularly among older adults (4). The prevalence of physical inactivity varies across studies and countries, partly due to differences in measurement methods (5). Addressing this global issue requires multi-level interventions and strategies to promote physical activity across diverse populations. Recent findings from a study conducted as part of the Erasmus+ project (project entitled: Movement Activity Enhancement After the COVID-19 Pandemic; project number: 2021-1-SK01-KA220-HED-000023008; acronym "COVIDMOVE") on university students in Poland, Slovakia, and the Czech Republic reveal the lasting effects of the COVID-19 pandemic on physical activity (PA) levels (6). Using the International Physical Activity Questionnaire Short Form (IPAQ-SF), the COVIDMOVE study found significant differences between the countries, with Slovak students exhibiting the highest median PA levels and Polish students the lowest. Despite meeting WHO recommendations for health benefits, overall PA levels have not returned to pre-pandemic levels, indicating persistent effects of the pandemic. These findings emphasize the need for targeted educational programs and initiatives to promote PA, particularly among women and populations at risk of adopting inactive lifestyles, to address the long-term consequences of reduced activity.

The health impacts of hypoactivity are profound and wide-ranging, affecting nearly every system in the body. It weakens the cardiovascular system by reducing heart efficiency and vascular elasticity, thereby increasing the risk of conditions such as hypertension (7), atherosclerosis, and coronary artery disease (8). Insufficient physical activity disrupts energy balance, impairs lipid metabolism, and promotes chronic low-grade inflammation, making it a key factor in the development of obesity, insulin resistance, and type 2 diabetes (9). Additionally, hypoactivity leads to musculoskeletal decline, including loss of muscle mass and strength (sarcopenia) (10) and decreased bone density (osteopenia or osteoporosis), which raises the risk of fractures and mobility impairments (11). A sedentary lifestyle can also weaken respiratory muscles and reduce lung capacity, potentially exacerbating conditions like chronic obstructive pulmonary disease (COPD) or postural respiratory dysfunction (12).

Beyond physical effects, hypoactivity is associated with an increased risk of mental health challenges such as depression, anxiety, and cognitive decline, as regular movement promotes the release of endorphins and supports neuroplasticity, both essential for mental well-being (13). Furthermore, physical inactivity is a leading modifiable risk factor for global mortality, contributing significantly to non-communicable diseases that account for the majority of deaths worldwide. These extensive impacts highlight the critical need to address hypoactivity as a significant public health issue by promoting regular physical activity and reducing sedentary behaviors across all age groups and populations.

**Cardiovascular diseases and hypoactivity**

The cardiovascular system delivers oxygen and nutrients to tissues and removes waste products. It includes the heart, blood vessels, and blood. Key functions are cardiac output (blood flow regulated by heart rate and stroke volume), vascular resistance (blood pressure control by artery tone), and endothelial function (vasodilation, coagulation, inflammatory regulation, oxidative stress regulation, and angiogenesis).

Cardiovascular diseases (CVD) are a leading cause of morbidity and mortality worldwide, encompassing conditions such as coronary artery disease (CAD), hypertension, heart failure, and arrhythmias. Among the various risk factors, physical inactivity or hypoactivity has emerged as a critical determinant of CVD development and progression. Gene-environment interactions play a crucial role in CVD development, with factors like smoking, physical activity, and diet modifying genetic risks (14). Network and systems approaches are being developed to elucidate the complex mechanisms underlying CVD (15). Hypoactivity increases oxidative stress, promotes endothelial damage, and contributes to dyslipidemia, with increased LDL and decreased HDL levels fostering plaque formation (16). Pro-inflammatory cytokines such as TNF-α and IL-6 exacerbate plaque instability. It also decreases arterial compliance, elevates blood pressure, and enhances sympathetic nervous system activation, contributing to sustained vasoconstriction. Prolonged hypoactivity leads to maladaptive changes such as left ventricular hypertrophy and reduced contractility while impairing energy metabolism in myocardial cells (17). Hypoactivity amplifies systemic inflammation, promoting vascular dysfunction, and induces insulin resistance, hyperglycemia, and dyslipidemia, which are major risk factors for CVD (18). It is strongly linked to weight gain, increasing mechanical and metabolic strain on the cardiovascular system (18).

The prevalence of CVD among inactive individuals is significantly higher compared to their physically active counterparts (19, 20). Regular physical activity has been shown to reduce the risk of CVD, coronary heart disease, and all-cause mortality (20). Even modest increases in physical activity can provide protective health benefits, with greater benefits observed at higher activity levels (21). Despite this evidence, a substantial portion of the population remains physically inactive (22). The economic burden of CVD associated with inactivity is significant, highlighting the need for increased efforts to promote physical activity (23). Demographic and socioeconomic factors play a role in predicting physical inactivity among CVD patients (22). Promoting physical activity across all age groups and ethnicities is crucial for improving cardiovascular health and reducing mortality rates (20).

Regular physical activity significantly reduces the risk of cardiovascular diseases (CVD) and associated mortality by 30-50% (24, 25). Exercise improves cardiovascular health through multiple mechanisms, including enhanced endothelial function, increased nitric oxide production, reduced oxidative stress, and decreased inflammation (26, 27). It also optimizes lipid profiles, improves insulin sensitivity, and lowers blood. These benefits can be achieved with as little as 30 minutes of moderate-intensity activity daily (25). Exercise-induced cardiovascular improvements are attributed to various physiological adaptations, such as enhanced fibrinolysis, improved endothelial function, and decreased sympathetic tone (28). While moderate exercise is generally recommended personalized exercise programs based on individual health status and fitness levels are becoming increasingly important for maximizing cardiovascular benefits (29).

**Metabolic diseases and hypoactivity**

Disorders in lipid and carbohydrate metabolism are central to the pathophysiology of chronic diseases like type 2 diabetes and cardiovascular disease. Dyslipidemia, characterized by elevated triglycerides, low HDL cholesterol, and increased LDL cholesterol, disrupts vascular function and promotes atherogenesis (30). Insulin resistance and physical inactivity are key factors in metabolic dysfunction, leading to impaired glucose uptake, hyperglycemia, and systemic inflammation (31). Type 2 diabetes mellitus (T2DM), metabolic syndrome, and obesity form an interconnected triad of metabolic disorders characterized by chronic inflammation, oxidative stress, and insulin resistance (32). These conditions share common pathophysiological mechanisms, including adipose tissue dysfunction, mitochondrial impairment, and hyperinsulinemia (33). The interplay between oxidative stress and inflammation creates a feed-forward cycle that initiates and advances disease progression, leading to complications such as cardiovascular disease and non-alcoholic fatty liver disease (34). Sedentary lifestyles and poor dietary habits are significant contributors to the development of these disorders (35). The complex relationship between these conditions is often referred to as the "Cardiovascular Metabolic Syndrome," emphasizing the need for a multi-pronged approach to prevention and treatment (36). The global prevalence of these interrelated disorders has reached epidemic proportions, posing significant challenges to public health systems worldwide (37).

Early lifestyle interventions targeting weight management, physical activity, and dietary improvements are critical for prevention and management. Also, a sedentary lifestyle and associated metabolic disorders significantly reduce quality of life and increase the risk of developing other chronic diseases. Individuals with obesity, type 2 diabetes, and metabolic syndrome often face significant physical limitations, fatigue, and psychological distress, including anxiety and depression, which adversely affect their health-related quality of life (HR-QoL) (38). Besides cardiovascular diseases, these conditions are linked to an increased risk of comorbidities such as certain cancers and musculoskeletal disorders (39). The cumulative burden of these diseases exacerbates functional impairments and elevates healthcare costs, ultimately shortening life expectancy (40, 41). Addressing physical inactivity and promoting healthier lifestyles are crucial for breaking this cycle (42). Furthermore, managing mental health issues like depression and diabetes distress is essential for improving disease management and overall well-being (43). Effective interventions can enhance quality of life and longevity for affected individuals (39).

**Respiratory diseases caused by hypoactivity**

Physical inactivity significantly contributes to the pathophysiology of respiratory diseases, particularly chronic obstructive pulmonary disease (COPD). It leads to reduced lung ventilation, impaired gas exchange, and loss of respiratory muscle mass and strength (44, 45). Inactivity is both a consequence and a potential cause of COPD, with low activity levels linked to faster lung function decline and increased COPD incidence. In COPD patients, physical inactivity is associated with disease progression, impaired health status, increased healthcare utilization, and higher mortality risk (46).

Similarly, recent studies suggest a complex relationship between physical activity and lung cancer risk. Leisure-time physical activity is generally associated with reduced lung cancer risk, particularly among current and former smokers (47). The protective effect of leisure-time activity appears dose-dependent, with higher levels offering greater risk reduction (48). This association is observed across various lung cancer subtypes (47). Proposed mechanisms include improved pulmonary function, enhanced immune function, and reduced inflammation (48). And finally, some studies indicate that individuals with asthma are less physically active than those without (49, 50). Factors influencing physical activity levels in asthmatic individuals include disease severity, parental beliefs, and body mass index (51, 52). A meta-analysis suggests that higher physical activity levels may be protective against asthma development (53). However, asthma is often perceived as a barrier to exercise by both children and parents (50). Some research indicates that children with asthma have higher rates of obesity and lower physical activity levels compared to those with other medical conditions (50).

These findings highlight the importance of physical activity and proper management of respiratory conditions in lung cancer prevention. The connections between hypokinesia and respiratory diseases, and the effects of COVID-19 on respiratory health have already been discussed in detail in this book within the chapter Impact of Physical Activity on Respiratory diseases, providing a comprehensive analysis of these topics.

Building upon the discussion of hypoactivity's impact on respiratory function, the findings from the Erasmus+ project further highlight the interplay between respiratory and postural functions and their implications for rehabilitation strategies. The studies conducted under the COVIDMOVE project collectively illuminate the intricate relationship between postural stability and respiratory function, emphasizing their relevance in rehabilitation science (54–56). A study reported by Sembera et al (55) examined the impact of abdominal bracing during load-lifting tasks on respiratory and postural function. The findings revealed that abdominal bracing increases diaphragmatic motion but reduces lung volumes, illustrating a trade-off between enhancing spinal stability and maintaining respiratory efficiency. Strong correlations were observed between diaphragmatic excursions and lung volumes, confirming the diaphragm's pivotal role in respiration even under heightened postural demands. These results are particularly relevant for individuals with respiratory limitations, such as those experiencing dyspnea, as the reduced lung volumes associated with bracing could potentially exacerbate breathing difficulties. This study highlights the importance of balancing postural and respiratory considerations in rehabilitation protocols, particularly for patients recovering from conditions that impair both systems. The same group of authors also investigated the postural-respiratory function of the diaphragm during load-lifting tasks using M-mode ultrasonography, spirometry, and abdominal wall tension (AWT) measurements (56). It demonstrated that load-lifting induced significant caudal displacement and increased diaphragmatic excursions, with greater AWT compared to tidal breathing. Importantly, the diaphragm's postural function remained independent of its respiratory activity, as breath-holding scenarios showed stable diaphragm behavior. The study also found that voluntary contraction of the abdominal muscles doubled AWT without reducing diaphragm motion, suggesting that diaphragmatic and abdominal muscle activity synergize to maintain adequate intra-abdominal pressure (IAP) and ventilation. These findings contribute to understanding the diaphragm's dual role in postural stabilization and respiration, with implications for rehabilitation and strength training strategies. The third study under the COVIDMOVE project assessed the inter-rater reliability of Dynamic Neuromuscular Stabilization diaphragm and intra-abdominal pressure regulation tests among patients with non-specific low back and neck pain (54). It found moderate reliability between experienced and novice DNS clinicians, with higher reliability noted in patients reporting greater pain intensity. These tests, which evaluate the diaphragm's dual role in postural stabilization and respiratory function, offer a practical and accessible method for clinical settings, addressing the need for reliable assessments of postural-respiratory dysfunction. This work, alongside the other studies in the COVIDMOVE project, highlights the diaphragm's critical role in postural stabilization and respiratory function, which are often compromised due to hypoactivity. Reduced physical activity can exacerbate dysfunction in these systems, emphasizing the importance of interventions that promote movement and restore postural-respiratory balance. Together, these findings provide a robust foundation for integrating respiratory and postural evaluations into rehabilitation protocols to mitigate the effects of hypoactivity and improve patient outcomes.

**Recommendations and interventions**

To mitigate the adverse effects of inactivity and enhance overall well-being, promoting physical activity across all age groups is essential. Prevention plays a pivotal role, with targeted strategies to encourage movement and reduce sedentary lifestyles. Recommended physical activities include aerobic exercises to improve cardiovascular health, strength training for muscle and bone health, and breathing exercises to enhance respiratory function. Programs and policies at both national and global levels should focus on creating accessible, inclusive opportunities for movement, such as community fitness initiatives and public awareness campaigns. A multidisciplinary approach is crucial for success, requiring collaboration among healthcare providers, physiotherapists, public institutions, and policymakers to ensure that interventions are comprehensive, equitable, and effective.

Exercise guidelines (1) for addressing hypoactivity focus on a range of objectives, including improving muscle strength and endurance to counteract the loss of muscle mass and functionality, and enhancing cardiovascular fitness to boost oxygen delivery, energy levels, and overall stamina. Mobility and flexibility exercises are emphasized to prevent stiffness and improve functional independence, while activities targeting neuromuscular coordination help reduce the risk of falls by enhancing balance and motor control. Regular physical activity is also highlighted for its role in reducing systemic inflammation and improving metabolic health by enhancing insulin sensitivity and lipid profiles, thereby addressing conditions like obesity and dyslipidemia. Additionally, the guidelines prioritize mental well-being, as physical activity is known to alleviate mood disorders such as depression and anxiety by boosting endorphin levels and improving sleep quality. A key focus is on fostering long-term behavioral change, encouraging individuals to integrate physical activity into daily routines and reduce sedentary behaviors to achieve sustainable health benefits across physical, metabolic, and psychological domains. However, one aspect that is not as often analyzed and emphasized within guidelines is the quality of posture during exercise as well as everyday activities.

As part of this strategy, the Erasmus+ COVIDMOVE was awarded to support initiatives promoting physical activity and recovery following the pandemic's impact. This collaborative project involved multiple institutions, including universities, research centers, and public health organizations from Slovakia, the Czech Republic, and Poland. The project's key outcomes include the development of comprehensive guidelines for physical activity programs tailored to post-pandemic recovery, the establishment of cross-border conferences for healthcare professionals, and the launch of public campaigns emphasizing the importance of regular movement. These efforts have effectively raised awareness about strategies to increase physical activity in both the general population and individuals with specific conditions, such as sarcopenia, mental health issues, pelvic floor dysfunction, breathing disorders, or digestive complications associated with respiratory disorders and lung transplantation.

**The importance of posture in exercise: The Dynamic Neuromuscular Stabilization (DNS) concept**

Proper posture is crucial for optimal body function and movement efficiency. It involves the alignment of body segments and maintenance of spinal curvatures (57). Poor posture can lead to musculoskeletal imbalances, pain, and reduced physical function (58). Exercise is widely recommended for preventing and correcting postural deviations by strengthening weak muscles and stretching tight ones (59). Various types of exercises, including strengthening, stretching, and specific postural exercises, have shown effectiveness in improving postural dysfunctions (58). However, the intensity, volume, and duration of exercise programs must be considered (58). While some studies suggest that exercise can correct postural deviations, there is a lack of reliable data to support this claim conclusively (59). Nonetheless, physical activity remains essential for maintaining good posture and overall health, particularly for sedentary individuals. One functional diagnostic and therapeutic concept that directly focuses on the analysis and training of posture is Dynamic Neuromuscular Stabilization (DNS) (60–62). DNS is a therapeutic approach rooted in developmental kinesiology, emphasizing the intricate relationship between posture and movement quality (60, 63, 64). DNS carefully analyzes posture by examining the alignment and function of the musculoskeletal system, focusing on how it supports optimal motor control during both static positions and dynamic activities. The concept is focused on core stability and optimal diaphragm function (54, 61, 65, 65, 66). Posture assessment within DNS involves a detailed evaluation of body alignment, respiratory patterns, muscle activation, and functional movement patterns (54, 61, 65, 67). Practitioners observe how the body maintains stability and compensates for dysfunctions, often identifying common examples of poor posture, such as forward head position, excessive lumbar lordosis, rigid thoracic kyphosis, or pelvic tilts. These postural imbalances frequently lead to inefficient movement patterns, increased strain on joints and muscles, and heightened risk of injury or chronic pain.

In DNS, the quality of movement is intrinsically tied to the quality of posture, as poor alignment disrupts the natural coordination of muscle groups and hinders the body's ability to generate efficient and balanced movements. For instance, improper posture can alter the activation of core stabilizing muscles, compromising stability and mobility during physical activities. DNS employs specific exercises that mimic developmental stages in early human motor development, such as rolling, crawling, or squatting, to retrain the neuromuscular system and restore functional movement (67). These exercises are designed to re-establish proper postural alignment and breathing mechanics while progressively challenging the body's ability to maintain stability under dynamic conditions.

The approach is strongly evidence-based, supported by research in biomechanics, neurophysiology, and motor control. Studies highlight its effectiveness in addressing musculoskeletal pain (68–73), improving athletic performance (74, 75), and enhancing rehabilitation outcomes by targeting the root causes of movement dysfunction. DNS is an effective approach for improving functional movements (76), postural control, and core stability (77). Studies have shown that DNS exercises can enhance chest mobility, upright sitting height, and quality of life in obese individuals (78). DNS has also demonstrated positive effects on core strength (79) and the functionality of the locomotor system (80). DNS exercises have shown promising results in treating various musculoskeletal and neurological conditions such as enhancing the performance and quality of life in stroke patients (81–83) or improving balance, gait, and gross motor function in cerebral palsy patients (84). Additionally, holistic therapy approach, including Dynamic Neuromuscular Stabilization (DNS), have demonstrated positive effects on fecal incontinence and quality of life in patients with multiple sclerosis (85). In sedentary female workers with mechanical neck pain, DNS training improved neck pain, cervical position angle, and muscle strength (86). For flatwater kayakers, DNS integration with traditional training increased maximum paddling force (74).

DNS provides a systematic, individualized framework for improving posture and movement quality, empowering individuals to achieve long-term health and functional resilience. By integrating principles of developmental kinesiology with rigorous scientific validation, DNS offers a holistic and precise method for addressing posture-related challenges in both therapeutic and everyday contexts. Overall, DNS appears to be an effective approach for promoting spinal stability, reducing pain, and enhancing functional performance across various populations (77, 79, 80).

**Integration of DNS in the brochures: outcomes of the COVIDMOVE project**

DNS is a core focus of the brochures developed for the Erasmus+ COVIDMOVE project. These materials emphasize the critical role of posture and movement quality in rehabilitation and overall physical health. Through these educational brochures, DNS incorporates the principles of developmental kinesiology, guiding individuals to achieve optimal body positions and movement patterns rooted in natural motor control. The brochures highlight DNS's focus on a self-treatment approach, empowering individuals to take an active role in their recovery and health management. This is achieved through education on proper posture and movement, helping patients improve their functional capabilities while preventing injuries and promoting long-term wellness.

A brochure entitled "Recommended Preparation for Selected Physical Activities, using the methodology of Dynamic Neuromuscular Stabilization (DNS)"(87) developed as part of the COVIDMOVE grant project, provides a comprehensive guide to integrating physical activity into daily life based on DNS principles. It emphasizes the importance of mindful movement and proper preparation to reduce the risk of injury and improve overall health. The document outlines key components of physical activity, including postural training, strength and cardiovascular exercises, and specific movement preparation for activities such as running, cycling, and swimming. It also highlights the need for gradual adaptation, quality of movement, and proper breathing techniques. The brochure serves as a resource for both individuals and professionals aiming to enhance functional capacity and promote long-term musculoskeletal health, particularly in the context of a global decline in physical activity post-COVID-19.

Another brochure entitled "Exercises for people with breathing disorders using DNS methodology" (88) provides a detailed guide to improving breathing patterns and strengthening respiratory muscles, particularly for individuals with breathing disorders or post-COVID-19 complications. It emphasizes the importance of proper breathing mechanics, the role of the diaphragm, and techniques to optimize respiratory function. Using the DNS methodology, the brochure offers exercises based on natural developmental positions, which enhance breathing capacity, trunk stability, and overall coordination. It highlights the need for gradual, mindful practice tailored to individual needs and encourages consulting professionals for personalized plans to achieve optimal results.

There is a clear link between hypoactivity (insufficient physical activity) and pelvic floor dysfunction (PFD), as the pelvic floor muscles (PFMs) play a crucial role in supporting pelvic organs, maintaining continence, and contributing to core stability. Hypoactivity can lead to weakened or poorly coordinated PFMs, increasing the risk of conditions such as urinary or fecal incontinence and pelvic organ prolapse. A sedentary lifestyle often results in muscle atrophy, poor core strength, and impaired blood flow, all of which hinder the ability of PFMs to function effectively. Additionally, physical inactivity can lead to weight gain, placing greater pressure on the pelvic floor and causing further muscle strain. Hypoactivity also disrupts the natural synergy between the PFMs and the diaphragm, essential for effective breathing mechanics and muscle coordination. A comprehensive overview of pelvic floor issues caused by hypoactivity, including the types and forms of urinary incontinence, its prevalence, and contributing factors such as age, childbirth, and physical activity levels, is provided in the chapter titled "Physical Activity in Incontinence Problems." It emphasizes the importance of proper diagnosis and assessment, including physical examinations, questionnaires, and advanced diagnostic tools. Furthermore, the chapter highlights various management strategies, from conservative treatments like pelvic floor muscle training and hypopressive exercises to pharmacological and minimally invasive approaches. Stressing the socio-economic and psychological impacts of incontinence, it advocates for tailored interventions to enhance quality of life and long-term management. Regular physical activity, including core and pelvic floor-specific exercises, is vital for maintaining PFM strength and reducing the risk of PFD. Therefore, another brochure produced as part of the COVIDMOVE project, entitled "Exercise for People with Pelvic Floor Dysfunction: Exercise Instructions" (89) focuses on addressing pelvic floor dysfunction by educating individuals on self-treatment techniques.

The COVID-19 pandemic has significantly impacted lung transplantation practices, with a notable increase in transplants performed for patients suffering from severe, irreversible lung damage due to the virus. A study published in JAMA Surgery in August 2023 analyzed data from the United Network for Organ Sharing (UNOS) database, identifying 385 patients who underwent lung transplants for COVID-19–related acute respiratory distress syndrome (ARDS) or pulmonary fibrosis between March 2020 and August 2022. The study found that the 1-, 6-, and 12-month overall survival rates for these patients were comparable to those of non–COVID-19 lung transplant recipients, indicating that lung transplantation can be a viable treatment option for patients with irreversible respiratory failure due to COVID-19 (90). Further supporting these findings, an analysis by the Smidt Heart Institute at Cedars-Sinai, published in The New England Journal of Medicine in January 2022, examined over 3,000 lung transplants performed in the U.S. between August 2020 and September 2021. The study reported that approximately 7% of these transplants were conducted to treat severe, irreversible lung damage caused by COVID-19, with a three-month survival rate of 95.6% among these patients (91). These studies underscore the evolving role of lung transplantation in managing severe COVID-19-related lung injuries, demonstrating that, with careful patient selection and management, lung transplantation can offer favorable outcomes for those with life-threatening pulmonary complications from the virus.

One of the potential causes of transplanted lung failure is gastroesophageal reflux disease (GERD). Addressing GERD in patients after lung transplantation is critical, as it can lead to pulmonary complications, impair lung function, increase the risk of both acute and chronic rejection episodes, and reduce survival rates in lung transplant recipients (92, 93). The prevalence of GERD is high among lung transplant patients, with over 50% affected (94). Early diagnosis and aggressive management of GERD, including antireflux surgery, have been shown to improve lung function and reduce complications in both pre- and post-transplant patients (95). Given the strong association between GERD and poor transplant outcomes, experts recommend thorough pre-transplant GERD testing and prompt intervention to potentially improve allograft function and survival (96, 97). Rehabilitation can have a positive effect on GERD in patients after lung transplantation by addressing several contributing factors. Firstly, targeted physical therapy can improve diaphragmatic strength and function, which plays a crucial role in preventing acid reflux by maintaining pressure in the lower esophageal sphincter (LES)(98–100). Secondly, structured exercise programs help with weight management, reducing abdominal pressure on the stomach, which is a known risk factor for GERD. Additionally, breathing exercises, often incorporated into rehabilitation, enhance coordination between respiratory and abdominal muscles, further supporting the LES's ability to prevent reflux (100). Overall, a comprehensive rehabilitation plan not only improves physical conditioning but also directly addresses the mechanical and functional aspects that contribute to GERD, benefiting patients post-lung transplantation. Therefore, a brochure was created as part of the COVIDMOVE project to educate post-transplant patients on postural and respiratory exercises aimed at preventing GERD. The brochure "Rehabilitation for Patients After Lung Transplantation with Gastroesophageal Reflux Using the Methodology of DNS" (101) provides a comprehensive guide for managing GERD in lung transplant patients. It highlights the risks GERD poses to lung health and offers targeted exercises to improve esophageal sphincter function, reducing reflux and its impact on lung function. Utilizing the principles of DNS, the guide emphasizes manual release techniques, breathing exercises, and postural adjustments to support respiratory health and mitigate complications. It also introduces tools like the Coach 2 and Acapella trainers for inspiratory and expiratory muscle training, enhancing lung capacity and function. These exercises are designed for regular practice and can be tailored to individual needs under the supervision of a physiotherapist.

**Conclusion**

The COVIDMOVE project highlights the vital role of physical activity and posture in addressing the widespread consequences of hypoactivity, particularly in the aftermath of the COVID-19 pandemic. Leveraging the principles of Dynamic Neuromuscular Stabilization (DNS), the project developed educational materials aimed at enhancing physical health through proper movement, breathing mechanics, and postural alignment. These materials, including brochures targeting breathing disorders, pelvic floor dysfunction, and GERD in lung transplant patients, integrate evidence-based strategies to empower individuals in their recovery and health maintenance. Feedback from physiotherapy students underscores the clarity, feasibility, and professional applicability of the materials, while also identifying opportunities for improvement, such as simplifying language and clarifying exercise instructions. By emphasizing the interplay between posture, movement, and overall health, the project provides a comprehensive approach to improving physical activity levels and mitigating the health risks associated with sedentary behaviors, ensuring its relevance and utility for both patients and healthcare professionals.

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