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Cycling is an Extremely Healthy Exercise that can be Enjoyed by Everyone

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Abstract

Cycling refers to an activity involving the use of bicycles. There are both advantageous and disadvantageous health effects associated with cycling. Possible dangers include falls and injuries, along with exposure to air pollution in certain cities. Nevertheless, the advantages of cycling significantly surpass the drawbacks, especially when contrasted with a lifestyle lacking physical activity. Cycling serves as a highly favored mode of transport, leisure activity, physical exercise, enjoyment, and competitive sport. It is believed that there are over a billion bicycles in circulation globally. In various regions, bicycles serve as the main form of transport. Furthermore, cycling is a well-respected professional sport and promotes both enjoyment and wellness.

Keywords: Cycling, Bicycle, Biomechanics, Health, Injuries

1. Introduction

Engaging in cycling, whether on a stationary bike or a traditional bicycle, can help maintain and enhance both aerobic and anaerobic stamina as well as leg muscle strength with minimal eccentric impact [1]. It serves as an excellent starting point for fitness regimens tailored for those who are unfit, elderly, or overweight. Cycling can also be utilized as a therapeutic option for injuries where running is not feasible. The development of the leg muscles can vary based on factors such as saddle height, pedal alignment, and handlebar design and positioning. Adjusting these elements can target specific muscle groups: for instance, an athlete recovering from an Achilles tendon injury can position the pedal beneath the heel to cycle. Individuals dealing with femoro-patellar pain or hip joint issues might need a higher saddle, whereas someone with hamstring injuries or back discomfort may benefit from an upright posture with elevated handlebars, and those experiencing carpal tunnel syndrome should refrain from excessively tight grips on the handlebars. A stationary bike available at a sports rehabilitation center allows for assessment and modification of seating arrangements, along with personalized training guidance.

There are very few injuries that prevent one from cycling, making it an excellent training option for individuals of all ages. Cycling can take place over varying distances, in intervals, in group classes, or solo; both intensity and pace can be modified to meet the needs of various athletes. Riding in rural areas is enjoyable, though it may become more challenging based on the landscape, weather, and traffic circumstances.

2. Focus

Cycling is pertinent to multiple areas within movement science, which encompasses elite competition, recreational activities, and exercise routines aimed at enhancing musculoskeletal and aerobic fitness and serves as a commonly utilized approach for rehabilitation targeted at numerous disorders related to physiological systems (such as injuries to the musculoskeletal system, neurodegenerative conditions, and cardiac recovery) [2]. In competitive environments, the main emphasis is on optimizing performance; the cyclist adopts a riding posture that is intended to reduce air resistance and enhance energy transfer to the bicycle. Studies involving top-tier competitive cyclists typically examine elements like bicycle parts (such as the design of frames and pedals), safety equipment (like helmet arrangements), aerodynamic postures while cycling, aerodynamic attire, as well as physiological and mechanical reactions to variations in load, body positioning, and frame configurations. Within the context of aerobic workouts, the key concerns generally revolve around comfort, safety, and the ability to adjust the cyclist's position, resistance levels, and pedaling speed in order to cater to a wide array of personal needs and objectives. Stationary bikes are frequently utilized as a method of aerobic exercise aimed at weight reduction and cardiac rehabilitation. Ultimately, individuals with specific musculoskeletal, cardiorespiratory, or neurodegenerative conditions (such as Parkinson's disease [PD]) leverage the rhythmic aspect of cycling to alleviate symptomatology associated with their illnesses (for instance, tremors in PD) and to enhance their overall health and wellness—a goal that is shared across all demographics.

Cycling distinctively merges lower-body strength enhancement, range of motion (ROM) improvement, and cardiovascular conditioning while managing stress on joints, tendons, and ligaments. It encourages rhythmic movements in the lower limbs (i. e. , cyclic loading) that are essential for the healing of ligaments, muscles, and tendons, as well as providing proprioceptive feedback to the central nervous system. Modifications can be made to a stationary bicycle to accurately fulfill the needs of individuals at different phases of their conditioning or rehabilitation journey. The extent of loading on the lower limbs, which can be modified through adjustments in the bicycle's resistance levels, along with the rate at which joints are moved, which can be controlled by changing pedaling speed and seat height, offers opportunities for precise measures to track improvement and gradually escalate exercise intensity. Cycling outdoors is another possibility; however, it is challenging to regulate the amount of muscular exertion and stress due in part to the significant inertial forces that occur, for instance, while riding uphill. Despite these challenges, outdoor cycling may be seen as less monotonous and more demanding, making it potentially appealing for athletes or patients who have progressed to more advanced stages of rehabilitation. Nevertheless, individuals involved in rehabilitation should receive thoughtful direction to guarantee that the advantages outweigh the potential risks that may arise.

3. Biomechanics

Biomechanics, which examines the internal and external forces impacting the body, is essential for engaging in any activity efficiently and safely [3]. Malfunctions in biomechanics can occur due to either static anatomical issues or functional irregularities. While static issues may be mitigated through the use of compensatory devices like orthotics, the functional alterations that stem from both the original problem and its remedy need to be addressed during training. Functional irregularities are typically easier to modify since they often result from injuries, incorrect techniques, or poorly calibrated equipment.

Two concerns need to be considered pertaining to gear. The initial one is an appropriate fit. Equipment that does not fit well adversely impacts biomechanics. The next concern is safety. Utilizing the correct protective gear during practice and events greatly lowers the chances of sustaining injuries.

The activity of cycling demonstrates how essential properly fitted gear is for facilitating effective biomechanics. The bicycle helps reduce the adverse impacts of both the repetitive cycling motion and the fixed posture the body maintains. When positioned on a bicycle with hands resting on the handlebars, alignment must ensure that the hands, shoulders, and front axle are in a straight line, and the rider's reach needs to allow a slight bend at the elbows while the hands rest comfortably on the brake hoods. This positioning keeps the wrists in a neutral state. Incorrect alignment can lead to the wrists bearing weight in an extended position, risking injury to the ulnar nerve, which travels from the upper arm to the side of the hand by the pinky. Ensuring a bike is tailored to the cyclist can avert this kind of injury. Additionally, ensuring the bike's specifications align with the rider guarantees that the seat is placed correctly. The height of the seat is crucial for maintaining proper pedaling biomechanics. An excessively high seat forces muscles to operate beyond their ideal length-tension ratio. Conversely, a seat that is set too low increases knee flexion and places added stress on knee joints.

Proper cycling shoes also positively influence biomechanics. In the context of cycling, footwear should be both comfortable and sufficiently rigid to facilitate efficient power transfer from pedal to leg. If this power transfer is poor, it can lead to increased strain on the lower limbs and lower back. Proper shoes should provide support for the feet, absorb shock, and offer good traction. The best footwear for an athlete will align with their unique biomechanical characteristics and the requirements of their sport. In some cases, a basic foot orthotic can help rectify anatomical issues.

The usage of protective gear is commonly advocated based on findings from medical professionals who determine a significant injury risk in certain sports or recreational activities. Protective equipment might encompass personal items like mouth guards and headgear, alongside external items such as padding around goalposts in American football. This gear must fulfill its designated purpose, fit properly, feel comfortable, allow for free movement, and should be worn whether athletes are practicing or competing. It should be replaced when it becomes worn or damaged and must adhere to the regulations of the specific sport. Protective equipment ought not to be shared among players of varying sizes and should be suitable for the player’s gender, covering the body parts most at risk of encountering impacts from other players or equipment.

4. Kinematics

Most studies concerning cycling kinematics have primarily focused on motion in the sagittal plane, specifically hip and knee flexion and extension, along with ankle dorsiflexion and plantar flexion [2]. The measurements of displacements, velocities, and accelerations for the thigh, shank (tibia), and foot are significantly influenced by the cadence and the design of the bicycle, such as seat height and crank length. Seat height is the measurement from the top of the pedal to the top of the saddle when the crank is positioned downward and aligned with the seat tube. The intricate relationships between bicycle design and rider kinematics, as well as efforts to improve the interaction between the bicycle and rider, have been explored in numerous studies which systematically altered rider kinematics by adjusting bicycle settings, pedaling cadence, or both factors. The peak flexion and extension motions of the joints in the lower limbs are affected by seat height and the adjustments made to the seat's position. Nevertheless, once the rider's position is set, the cyclic movement of the lower limbs remains relatively stable.

Kinematic, kinetic, and muscle activity patterns during cycling are typically discussed in relation to the angle of the crank; where 0° or 360° indicates the top dead center (TDC) and 180° signifies the bottom dead center (BDC) when cycling in an upright position. The phase responsible for power or propulsion occurs between TDC and BDC, while the opposite limb is engaged in the recovery phase from BDC back to TDC. It is important to note that in recumbent cycling, the power phase shifts approximately 90°, placing it between 270° and 90°.

Kinematic information, such as the range of motion at each joint, varies based on the configuration of the bicycle. While both linear and angular displacements, as well as velocities and accelerations, adapt with changes to bike fitting, it is beneficial to provide examples related to steady-state seated cycling performance.

5. Fit

The geometry of frames can be categorized into several broad types: road racing, touring, mountain biking, and BMX [4]. The conventional ‘double diamond’ frame style remains the most common, although many monocoque designs and alternative geometries are increasingly appearing.

Frame dimensions are ideally established based on the cyclist's overall stature and cycling technique. The cyclist's height and reach influence how the top of the head tube and handlebars are situated, which in turn affects the frame size. This is due to the fact that, unlike with the saddle, there are limited options for adjusting handlebars and stems effectively. A common element in achieving a comfortable fit is the center of gravity. For the majority of cyclists, having the center of gravity positioned slightly ahead of the bottom bracket spindle leads to a more comfortable experience. However, this principle is not absolute. In the case of a professional time trialist in an aerodynamic stance, the center of gravity is typically shifted further forward. For the "typical" rider exhibiting "average" body measurements, a satisfactory seat configuration can be found by adhering to the knee-over-spindle guideline. This method involves placing the seat such that a perpendicular line dropped from the tibial tuberosity intersects the pedal spindle of the forward leg when the crank is horizontal. While this may not be ideal for every cyclist, it serves as a solid foundation. For instance, a cyclist with longer femur proportions might discover that this seat positioning causes the center of gravity to be too far back. When cycling, it is preferable for the rider to bear most of her weight through her legs, which usually push down on the pedals. Some of the weight should rest on the saddle and hands, although the hands are the least accommodating when it comes to supporting weight.

Kinematic information, such as the range of motion at each joint, differs based on the configuration of the bicycle. While both linear and angular movements, as well as speed and acceleration, shift with alterations in bike fitting, it is beneficial to illustrate a few instances of steady-state seated cycling efficiency.

6. STA

The angle of the seat tube (STA) dictates the location of the saddle and the alignment of the hip axis in relation to the crank axis [4]. There are different perspectives regarding what constitutes the 'ideal' STA. Historically, competitive road cyclists have favored STAs ranging from 72° to 76°, in contrast to triathletes who often prefer steeper STAs that can reach between 80° and 90°. As the frame size increases, the STA usually decreases since it primarily indicates the length of the femur. This adjustment enables taller cyclists with longer femurs to reposition themselves backward, thus preserving the body's center of gravity. Additionally, the STA can be effectively modified by adjusting the seat forward or backward. Various cycling disciplines and styles are characterized by distinct geometries. For instance, mountain and touring bicycles typically feature shallower STAs designed to facilitate climbing while seated.

The ideal saddle height has been assessed in relation to oxygen usage and the kinematics of the lower limbs. The lowest oxygen consumption is observed at around 100% of the trochanteric height or between 106% and 109% of the symphysis pubis height. To determine leg length accurately, the subject should wear cycling shoes, maintain a 30 cm distance between feet, stand straight, and keep their back against the wall. The saddle height is calculated from the pedal at its farthest point from the seat to the upper section of the seat aligned with the pedal axis. A more straightforward and less technical method for adjusting saddle height involves sitting comfortably on the bike with the heels on the pedals and pedaling backward. The leg should extend fully while the foot remains flat. Then, clip in and start pedaling. At the lowest point of the stroke, the knee should be slightly bent, with suggestions ranging from 15 to 30°. When viewed from the rear, the hips should not sway back and forth to gain extension, indicating that the saddle may be positioned too high. Another sign of excessive seat height is seen in excessive ankle movement, where the rider attempts to reach the bottom of the pedal stroke. Moreover, a saddle set too low can lead to increased patellofemoral pressure, as the knee undergoes more flexion with each pedal rotation.

In cases of limb length discrepancies, it is most straightforward to adjust the bike to accommodate the longer leg. The shorter leg needs to be assessed to identify whether the discrepancy is mainly due to the tibia or femur. If the difference is tibial, remedying the issue can be achieved by adding a lift or shim that is slightly less than the full discrepancy between the cleat and shoe. If the discrepancy is femoral, a lift of about half the difference should be combined with repositioning the shorter leg slightly backward on the pedal. Additionally, a shorter crank can be utilized for the shorter leg to address limb length differences.

Crank length serves as a crucial element in the transfer of energy from a cyclist to their bicycle. The ideal length of the crank arm is influenced by various factors, especially the rider's style, which may involve sprinting, touring, participating in time trials, or climbing hills. Each riding style has its optimal crank length; for instance, utilizing longer crank arms can enhance leverage while reducing pedaling speed, which is beneficial for driving larger gears. Typically, taller individuals experience optimal cost efficiency with longer crank lengths and slower pedaling speeds, as compared to shorter individuals. It's not unusual for a shorter woman to utilize a longer crank arm, leading to increased hip and knee flexion at the peak of the pedal stroke. Maximum mechanical power output is generally observed with a leg length to crank length ratio of 6. 3:1 (measured from the trochanter to the floor in centimeters). As a general principle, shorter cyclists should use crank arm lengths ranging from 165 to 166. 5mm, while those under 1. 5 meters tall might opt for 160mm. Cyclists standing between 1. 6 and 1. 8 meters should select a crank arm length of 175mm. In the context of mountain biking, a length of 177. 5mm is advisable.

7. Kinetics

A thorough kinetic examination of the functions of the lower limbs necessitates an understanding of the forces that interact between the cyclist and their bike [2]. According to Newton's third law of motion, forces always arise in pairs, which have equal strength but act in opposite directions. Thus, when pressure is exerted by the foot onto the pedal, there is an equal yet opposite reaction force acting on the foot. These reactive forces, known as pedal reaction forces, engage the foot during cycling and have been extensively measured in various laboratories through the use of specialized pedals. The designs of these pedals are fundamentally akin to force platforms commonly employed to assess ground reaction forces during walking. Various force components perpendicular to the pedal's surface, along with shear forces that are parallel to the pedal plane—in both mediolateral and anteroposterior directions—have been well-documented. From these forces, a center of pressure, or the specific point where the force is applied, can be computed. Additionally, a rotational moment around an axis that is perpendicular to the pedal surface, located at the center of pressure, can be calculated, and this has been utilized to observe cycling performance in relation to injuries. Although pedal reaction forces have been documented for over a century, the intricate nature of the instrumentation used for measurements has not significantly altered the standard profiles of pedal reaction forces in seated positions. The impacts of load, pedaling speed, and rider positioning on the bike with respect to both the intensity and direction of these force components are elaborated upon later in this section.

Beyond just the intensity of the pedal reaction force, the alignment of the resultant vector in relation to the lower limbs is a critical aspect that significantly affects how the musculature in the legs reacts to diverse pedaling stresses.

8. Blood Flow

Skeletal muscle circulation is crucial for enhancing the performance of both short and long-duration exercises [5]. Consequently, skeletal muscles have an adequate circulatory ability to supply blood for different workout activities. A significant part of this capability arises from the diversity and makeup of muscle fibers. For instance, red muscle fibers are abundant in myoglobin and oxidative enzymes, contributing to their reddish color. These fibers also possess three times more capillaries for each fiber compared to white fibers, which are typically known for their glycolytic characteristics.

At rest, the blood flow to skeletal muscles ranges from 750 to 1000 ml. min−1, equivalent to 2–4 ml. 100 g−1 of muscle per minute. This accounts for approximately 15–20 % of the total cardiac output and consumes around 25 % of the metabolic rate at rest in terms of oxygen uptake. Nevertheless, the oxygen consumption in specific muscles can surge by fifty times when moving from a resting state to maximum exertion. Therefore, during maximum aerobic activity, the working muscles can receive between 80–85 % of the highest cardiac output achievable. In a person weighing 75 kg, skeletal muscles make up roughly 30 kg, which is about 40–45 % of their body weight. With a VO2max capacity of 3500 ml. min−1 and a peak cardiac output of 22,000 ml. min−1, this individual's total muscle blood flow could potentially reach or surpass 18,000 ml. min−1 (60 ml. 100 g−1. min−1). However, during intense whole-body activities like running, roughly 50 % of the total muscle mass is actively participating. Therefore, if 15 kg of muscle mass were fully engaged, blood flow to those active muscles would increase to 120 ml. 100 g−1. min−1. In the case of someone with a VO2max of 6300 ml. min−1 and an equal muscle mass, such as a highly trained endurance athlete, total blood flow to the muscles would be 33,600 ml. min−1 (approximately 224 ml. 100 g−1. min−1). During cycling routines, which utilize less total muscle mass (10 kg), muscle perfusion could theoretically rise to 336 ml. 100 g−1. min−1.

The maximum level of muscle perfusion in well-conditioned cyclists has been noted to exceed 380 ml. 100 g−1. min−1 during maximal knee exercises with a single leg. During this kind of workout, the absolute increase in muscle blood circulation can jump from 300 to 10,000 ml. min−1 in under ten seconds. This showcases a remarkable capacity and flexibility of the muscle blood vessels in reaction to intense physical activity. It also emphasizes the close relationship between muscle blood flow and the oxygen needs of the muscles in motion. To satisfy these needs, various circulatory modifications happen to ensure that perfusion pressure and vascular conductance are satisfied, particularly during full-body exercises. For example, blood pressure is not only sustained but also rises in proportion to the level of exercise intensity. Flexible vascular areas, like those in the splanchnic and cutaneous regions, constrict to redirect blood flow towards the active muscles, initiating the muscle pump, which simultaneously increases the circulating blood volume. In general, muscle blood flow stabilizes within a window of 30–90 seconds depending on the intensity of the exercise, remaining relatively constant during prolonged steady-state physical activities.

9. Training

When an individual embarks on a training regimen for the initial time, the training should occur only every other day [6]. This approach is particularly beneficial for high-impact activities such as running, as it provides sufficient time for recovery and adaptation between sessions, particularly for the weight-bearing bones of the legs. The process of bone adaptation is notably gradual. In fact, during the first approximately three months of beginning a weight-bearing training regimen, the bone initially decreases in strength. After this phase, the osteoblasts become highly active and new bone formation begins. Therefore, until this period is completed, there is a significantly heightened risk of experiencing a bone stress injury if the training intensity escalates too quickly. The frequency of weekly training sessions should only be augmented after ensuring that the duration of each session held every other day has reached an adequate length. This evaluation is contingent on the specific sport and the available training time. For instance, in a running program that subjects the body to considerable weight-bearing stress, it is advisable to adopt a more gradual approach to increasing training frequency than one would in a sport like cycling. In cycling, the constraints are more often associated with how swiftly the muscles adapt, which occurs at a quicker rate than bone adaptation. The transition from training every other day to a more frequent schedule should follow a well-structured plan. Initially, training every other day should progress to training two consecutive days followed by a day of rest. This progression can then move to three days in a row, then four days, and so on, allowing for sufficient time at each consecutive "step" before advancing to the next level. At the most intense levels of training, it is typical for elite athletes to engage in daily workouts, with two training sessions on five or six days of the week.

10. Injuries

Factors contributing to the risk of overuse injuries in cycling include mistakes in training, poor pedaling form, unsuitable bike adjustment, anatomical misalignment, biomechanical issues, muscle discrepancies, and insufficient cycling gear [7]. For all cyclists facing injuries, it is essential to assess training distance and intensity, engagement in other athletic activities (as many cyclists participate in cross-training or strength training), bike fitting, anatomical aspects like muscle imbalances, lower body biomechanics, flexibility and range of motion, differences in limb length, and history of prior injuries. As with any athlete, modifying activities and addressing symptoms is crucial for the treatment of injured cyclists.

There is a notable absence of evidence-based biomechanical approaches for treating cycling injuries. Numerous seasoned specialists in sports medicine related to cycling often resort to anecdotal and trial-and-error methods. There is a consensus among authors that rectifying biomechanical issues is vital in preventing the reoccurrence of injuries for many cyclists. Excessive pronation of the subtalar joint has been associated with conditions such as patellofemoral pain, iliotibial band syndrome, Achilles tendinitis, plantar fasciitis, metatarsalgia, and forefoot neuritis. Conversely, limited pronation of the subtalar joint and cavus foot type have also been linked to sesamoiditis, Achilles tendinitis, extensor tendinitis, metatarsalgia, and forefoot neuritis.

11. Conclusion

Cycling represents a wonderfully healthy activity suitable for individuals of any age. Furthermore, it is an enjoyable pursuit, particularly when discovering unfamiliar pathways. Notably, it is also budget-friendly. For anyone interested in taking up cycling, acquiring a suitable bicycle that aligns with their specific preferences and needs is essential. If someone intends to participate in more challenging cycling activities, it is advisable to invest in extra safety gear.

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