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Sudharani P
Assistant Professor, Department of Biotechnology, GITAM, Deemed to be University, Visakhapatnam, India

Kishan KPC
Professor, Department of Entrepreneurship, GITAM, Deemed to be University, Visakhapatnam, India

Ramamohanrao M
Professor, Department of Entrepreneurship, GITAM, Deemed to be University, Visakhapatnam, India

Manjulatha C
Professor, Department of Zoology, Andhra University, Visakhapatnam, India

Corresponding Author:
Sudharani P
Assistant Professor, Department of Biotechnology, GITAM, Deemed to be University, Visakhapatnam, India

Exercise physiology-walking vs cycling with reference to knee joint loading

Sudharani P, Kishan KPC, Ramamohanrao M and Manjulatha C

Abstract
Regular physical activity is a well-established protective factor for the prevention and treatment of the leading non-communicable diseases. Walking and cycling are enabling people to engage in regular physical activity on a daily basis and key means of transportation which is environmental concern as well. But, continuous and prolonged walking results in an increase in knee pain and blunting of clinical benefits, whereas interval walking did not lead to it. On the other hand, cycling is usually classified as a low-demand activity for the knee joint and is therefore recommended even for persons with osteoarthritis and rehabilitation programs following knee surgery. However, there is limited data regarding actual joint loading. The present review is carried out in a view to find the benefits of walking and cycling when done at periodic intervals. The choice of regular walking alternated with cycling may result in positive health considerations. Further research will help to direct a large group of people to a better option of physical activity with respect to actual joint loading.

Keywords: Physical activity, joint loading, knee pain, walking, cycling

Introduction
Physical activity is essential for public health [1]. Walking and cycling are known to lower the risk of non-communicable diseases and mortality [2-7]. During these activities, the human knee joint is subjected to significant loads with peak loads well above body weight [8-12]. Continuous and prolonged walking results in an increase in knee pain and blunting of clinical benefits [13], where as interval walking did not lead to increased knee pain [14]. As such, long duration walking in patients with knee osteoarthritis has been hypothesized to lead to quadriceps muscle fatigue, loss of effective shock absorption and higher rates of knee joint loading, which can lead to increased pain and greater cartilage damage [15]. Moreover, discontinuous or intermittent walking, keeps the same expenditure of calories as continuous and prolonged walking [16].
On the other hand, bicycling across the globe is increasing as a means of exercise and transportation. The overall health benefits of cycling are tremendous. Cycling reduces the incidence of cerebrovascular accidents, coronary artery disease, hypertension, dyslipidemia, obesity, and diabetes mellitus [17]. Despite these benefits, cycling commonly leads to injury, with up to 85% of all recreational cyclists citing an overuse injury. Given unbalanced pressure distribution when on the bike, the neck, hands, wrists, lower back, knees, and perineum are the regions most frequently affected by cycling [17]. When compared with continuous cycling protocol, the intermittent cycling that enhances executive functions following physical activity suggesting that, an intermittent protocol might have the potential to fit and effects will be of a greater magnitude and last longer [18].
As the present data appears to be turning against the approval, for continuous walking or cycling workouts, this pilot study sought to gain some insight into the potential benefits of an interval walking and cycling program as an alternative exercise option [19], focusing on knee joint force during the activity.

1.1 Literature Review
Recent research was done on effect of brisk walking on physical fitness of elderly [20], Physiological Effects of Individuals with Knee Osteoarthritis in Golf [21] and effects of Long-

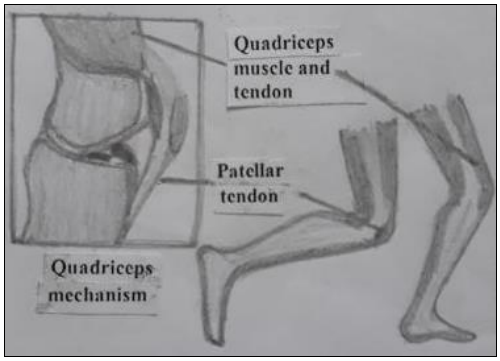
Long-Term Regular Continuous and Intermittent Walking in Older Adults with Hypertension [22]. The acute effects of continuous and intermittent cycling on executive function in children[18], differences in attitudes of walking and cycling [23], Influence of saddle setback on knee joint forces in cycling [24], the effect of cycling in older adults [25], a cross-sectional analysis of accelerometer in adults of Copenhagen City [26], intensity of cycling for knee osteoarthritic patients [27], changes in cycling and mortality risk[6], effects of walking interventions among inactive healthy adults[2] are discussed at various periods.

World Health Organization put forwarded a Global action plan 2018-2030 on physical activity of more active people for a healthier world [1]. Further, the Influence of Continuous Versus Interval Walking Exercise on Knee Joint Loading and Pain in Knee Osteoarthritis patients [14], cycling and type 2 diabetes risk [7]: bicycling and prevention of Cardiovascular Risk [5], cycle training and muscle hypertrophy [28], effects of moving forward or backward on the saddle on knee joint forces during cycling [29], loading of the knee joint during ergometer cycling [30] are also studied. Continuous and intermittent walking alters HDL (2)-C and LCATa[16] and individual Muscle Contributes to the Axial Knee Joint Contact Force during Normal Walking [31] knee moments and shear after total knee arthroplasty [9], alterations of neuromuscular function after prolonged running, cycling and skiing exercises [19], Tibio-femoral loading during human gait and stair climbing [12], the role of muscles in joint adaptation and degeneration [13] were investigated previously.

Effects of continuous and discontinuous walking on physiologic response [32], Obesity and osteoarthritis of the knee [15], mortality associated with physical activity during leisure time [4], the three-dimensional determination of internal loads in the lower extremity [10], load moments about the hip and knee joints during ergometer cycling [33] were analyzed by different researchers.

1.2 Knee physiology of walking

Muscles can have significant contributions to forces at joints, they do not span. Few studies have investigated how the major lower-limb muscles contribute to the knee joint contact forces during walking. Muscles spanning the knee joint can generate greater tibio-femoral joint forces than the forces developed in the muscles themselves, and muscles that do not span the knee joint can have significant contributions to the tibio-femoral joint forces through their contributions to the ground reaction forces [31]. Tightening up the quadriceps muscles places a pull on the tendons of the quadriceps mechanism. This action causes the knee to straighten. The patella acts as a fulcrum to increase the force of the quadriceps muscles (Plate 1).



Plant 1: Quadriceps mechanism

The long bones of the femur and the tibia act as lever arms, placing force or load on the knee joint reaction forces of the lower extremity (including the knee) are two to three times the body weight during walking and up to five times the body weight when running. As long as the walking is continuous, the force on knee joint also will be continuous [31].

1.3 Knee physiology of cycling

The primary power-producing muscles used for cycling include the quadriceps, hamstrings and gluteals, which will work continuously if it is regular cycling [34] (plate 2). The calf muscles, abdominals and erector spinae in conjunction with upper body muscles are used for stability during the activity [35].

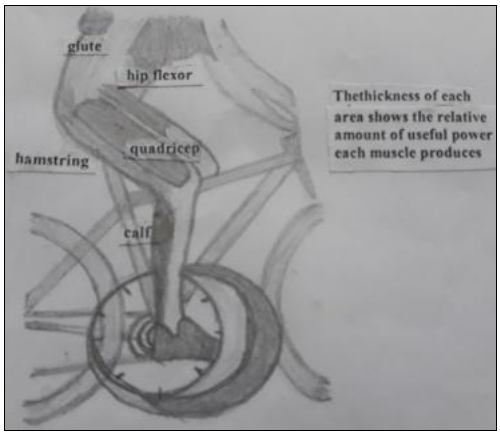


Plate 2: Muscles used during a pedal stroke

The knee joint acts as a lever to the femur, as the it is the longest bone in the body. This can create large amounts of torque where the patella acts as a fulcrum and enables the force from the upper leg to be transferred to the lower leg. There are two main phases of the pedal cycle; Power phase, where all the force is generally generated to propel the bike forward and the recovery phase.

2. Discussion

Non-communicable diseases are a major burden worldwide[36]. For public health, walking remains firmly a 'best buy'. Exercised muscle tissue is in constant state of re-modelling, leading to increase in endurance, flexibility and power [37]. Walking interventions benefit a number of cardiovascular disease risk factors [2]. It is the ideal physical activity mediation to improve health across the population [38]. Further, brisk walking improves cardio respiratory fitness, muscular strength, and body composition among the elderly was proved [20]. But, there are fewer studies on the effects of flexibility, muscular endurance and life satisfaction. Continuous walking results in an increase in knee pain, interval walking did not lead to it [14]. Practicing long-term regular continuous and intermittent walking may hold potential for increasing antioxidant and decreasing lipid peroxidation, thus alleviates oxidative stress in older people with hypertension. Moreover, those who will practice continuous walking exhibits greater improvement in metabolic profile, while the others with intermittent walking shows greater improvement in cardiac autonomic function [21]. Additionally, with reference to knee contact force, significant increase from baseline was observed in peak knee contact force during the weight-acceptance phase of gait after 30 and 45min of walking, irrespective of the walking exercise condition.

Muscles are significant contributors to the high joint forces developed in the knee during human walking. Not only do muscles contribute to the knee joint forces by acting to compress the joint, but they also develop joint forces indirectly. The soft tissues around the knee absorbs most of the external shear forces during walking, stair climbing, chair-rise, and squat activities [9]. Further, small changes in walking kinematics can have a significant effect on the magnitude of the knee joint forces. Thus, altering walking mechanics and muscle coordination patterns to utilize muscle groups that perform the same biomechanical function, yet contribute less to the knee joint forces may be an effective way to reduce knee joint loading during walking [31]. The choice to walking/cycling is related to health considerations and environmental concerns [23]. Leisure time physical activity was inversely associated with all-cause mortality in both men and women in all age groups. Benefit was found from moderate leisure time physical activity, with further benefit from sports activity and bicycling as transportation [4]. Cycling between one and sixty minutes per week was associated with lower risk of all-cause mortality for commuter cycling when compared with no cycling [6].

In bicycling, the peak compression force was related to neither pedal force nor quadriceps muscle force but coincides with the eccentric contraction of knee flexor muscles. Further, incorrect bicycle configuration may affect knee joint forces during pedaling [24]. Individuals being overweight or obese, being low participation in physical activities such as cycling and walking should be targeted in future initiatives towards an active, healthy society [26]. Both pedal cycles and e-bikes can enable increased physical activity and potentially providing greater benefits [25]. Cycling demonstrated significant benefits with the High Intensity Interval Training than Moderate Intensity Continuous Training in health-related quality of life and functional performance [27]. Whether the cycling may be continuous or intermittent expends the same number of calories [16]. Knee contact force and knee pain was reported higher during a continuous 45-minute bout of walking exercise compared to completing the same volume of exercise in an interval format [14]. These findings are in support of the present opinion of intermittent walking and cycling as a better option of healthy physical exercise (Table 1).

Table 1: Comparison of physical activities with related body factors

Type of physical activity/ related factor	Continuous walking	Intermittent walking	Continuous cycling	Intermittent cycling	Walking vs. Cycling
Loading on the knee joint	More	Less	More	Less	Intermittent walking or cycling is preferred than continuous Walking or Cycling
Knee pain	More	Less	More	Less	Intermittent walking or cycling is preferred than continuous Walking or Cycling
Fitness of heart and lungs	strenuous	well-fit	strenuous	well-fit	Intermittent walking or cycling is preferred than continuous Walking or Cycling
Impact on muscles	strenuous and become fatigue	Muscles relax	strenuous and become fatigue	Muscles relax	Intermittent walking or cycling is preferred than continuous Walking or Cycling
Muscular strength and endurance	Decreases	Stable for longer periods	Decreases	Stable for longer periods	Intermittent walking or cycling is preferred than continuous Walking or Cycling
Release of stored fat	Excess fat will be released	Excess fat will be released	Excess fat will be released	Excess fat will be released	Intermittent walking or cycling is preferred than continuous Walking or Cycling
Potential energy of the body	Gradually decreases	Increases	gradually decreases	Increases	Intermittent walking or cycling is preferred than continuous Walking or Cycling

Cycle training induces muscle hypertrophy similarly between young and older age groups, while strength gain seems to favor older adults, which suggests that the probability for improvement in muscle quality appears to be higher in older adults compared to young adults. For young adults, higher-intensity intermittent cycling may be required to achieve strength gains [28]. Therefore, cycling alternated with walking results in strength gaining among all age groups.

Cycling is also a recreational activity and mode of commuting with substantial potential to improve public health in many countries around the world. Commuter and recreational cycling, late-in-life initiation of or continued engagement was consistently associated with lower risk of hyperglycemia [7]. Small increases in knee flexion angle (5-6°) explains trivial differences in patellofemoral and tibiofemoral compressive forces. Tibiofemoral shear force may be more sensitive to changes in knee joint angle compared to other knee force components [29]. Cycling is usually classified as a low-demand activity for the knee joint. However, there is limited data regarding actual joint loading. Within the examined power range, tibiofemoral forces during cycling especially in ergometric (in vivo, ergometric) are smaller than those during walking [30]. Due to the relatively small tibiofemoral forces, cycling with moderate power levels will be suitable for individuals with osteoarthritis and rehabilitation programs following knee surgery, such as cartilage repair or total knee replacement.

Muscles are the primary contributors to joint loading. In cycling, some central activation deficit has also been observed for knee extensor muscles but central fatigue after activities inducing low muscular damage was attenuated compared with running [19]. These studies will further hold up the concept of intermittent walking and cycling, with reference to muscular damage. Muscle health and muscle rehabilitation are key components for the successful prevention of, and recovery from, joint injury and disease [13]. It is hypothesized that long-duration walking (e. g. 20 min) in the elderly obese will lead to quadriceps fatigue [15]. Even, planar movements such as

walking and running are also associated with significant inter segment muscle moments depending on load capabilities [10]. Continuous and discontinuous walking is equally effective in maintaining, but not improving the maximum absorption and utilization of oxygen [32]. Thus, an alternative fitness activity which can fill the gap may be added for routine.

The maximum hip and knee joint load moments induced during cycling were small compared with those obtained during other exercises or normal activities such as level walking, stair climbing, and lifting [33]. The acute effects of intermittent cycling will be of a greater magnitude, last longer, elicit higher values of arousal and consequently improve cognitive performance than continuous cycling [18]. These findings indicate that an alternative cycling with walking may minimize the knee joint load.

3. Conclusion

Physical activity is important across all ages which can and should be integrated into the settings in which people live, work and play. Walking and cycling are key means of transportation and enable engagement in regular physical activity on a daily basis, but their role and popularity is declining in many countries. Walking exercise duration in multiple bouts as opposed to one continuous bout may be beneficial for limiting knee pain. Small changes in walking kinematics (e.g., knee flexion angle) can also have a significant effect on the magnitude of the knee joint forces. Cycling on the other hand, demonstrated significant benefits in health-related quality of life; whether it may be continuous or intermittent, expends the same number of calories. Thus, limiting high impact physical activities may minimize the knee joint load. Therefore, the choice of regular walking alternated with cycling may result in positive health considerations. Further research will help to direct a large group of people to a better option of physical activity that improves muscle function with respect to actual joint loading.

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