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**ORIGINAL ARTICLE**

# CURRENT ISSUES RELATED TO BIOMECHANICS IN ENGINEERING

A.H.Hilmi[1],A.R.A.Hamid[1,2]

Faculty of Mechanical Engineering Technology, Universiti Malaysia Perlis[1]

humaizi@unimap.edu.my[1]

*Abstract: Motion capture was employed by Eadweard Muybridge and Etienne-Jules Marey. Industry standard for computing joint kinematics is motion capture. Kinematic analysis is a technique used in biomechanics and mechanical engineering to quantify stiff body motion. A joint moment can be computed in one of two ways: bottom-up or top-down. Joint moments measure muscle and joint tension indirectly. Researchers predicted joint moments using kinematic-based characteristics and machine learning outside of the biomechanics lab.Ankle osteoarthritis causes significant biomechanical issues in the foot and lower leg. Patients' 3D multi-segment kinematic foot models were studied. The technique used is Openpose, which recognises the human body from a single photograph.Falling fear is linked to decreased activity, despondency, and anxiety in the elderly. They adopt a hip approach to manage their GRFs and balance. The lateral ankle technique corrects minor foot placement problems by swiftly moving the pressure point. Angular momentum is affected by foot placement and ground reaction forces. Changing the body's centre of mass along a curved trajectory implies large changes in both ground reaction force impulses and ground reaction force.Lens stiffness and a ciliary muscle anterior/inward displacement produce presbyopia. By 55, the majority of folks have lost their ability to accommodate. Cataracts become common around this time, reaching over 70% by 75. The circumferential and meridional stiffnesses rose with anisotropy from pole to equator, but dropped with distance. The Holzapfel model accurately fits the data from inflation and uniaxial mechanical tests.Anatomical motions of the femur during knee flexion were examined. The data revealed morphological and physiological knee kinematic characteristics. The data led to several hypotheses about axial femoral condyle rotation. This review discusses lower limbs, foot positioning, lens capsule, femoral condyle, muscle activation, collagen fibre, knee joint, and walking speed. The purpose is to provide a general overview on the subject matter.*

**Keywords: Biomechanics, lower limbs, foot positioning, lens capsule, femoral condyle, muscle activation, collagen fiber, knee point, walking speed**

## 1.0 INTRODUCTION

Biomechanics research has looked at how people move since the early 1900s, when Eadweard Muybridge and Etienne-Jules Marey used motion capture to look at how people moved. Using motion capture to figure out how joints move and how they move became the standard way to figure out how joints move and how they move through skeleton modelling applications that include an outside force. [1] In order to better understand how people move, researchers have used this technology to describe how people move in a variety of ways, such as on a treadmill, on a ramp, and on the ground, as well as the topography of each mode. [2] Kinematic analysis is a way to figure out how stiff bodies move in clinical and research biomechanics, as well as in mechanical engineering. Kinematic research is used a lot in biomechanics, but the methods used to figure out three-dimensional (3D) segment position and orientation (pose), as well as the kinematics produced by these methods, are different. Motion capture that doesn't use markers on the skin can help solve some of the technical and practical problems that arise with marker-based motion analysis. This is done by using neural networks that have been trained to replace manual palpation and skin surface marker tracking of bone landmarks with probabilistic predictions of where these landmarks will be. It is possible to figure out the posture of body parts that are represented by local coordinate systems (LCS) and global coordinate systems (GCS) by using at least three non-collinear markers or landmarks in both systems. If researchers wants to apply classic marker-based motion analysis, they must first identify precise anatomical landmarks via professional physical palpation in order to construct coordinate systems and the joints at their centres, which together comprise the model. To be good at this skill, the researcher need to know a lot about anatomy and be able to apply that knowledge to a specific person. [3] Joint moments are used a lot in biomechanics research because they are a way to figure out how muscles and joints work and how much stress they put on them. Using joint moments, researchers were able to better understand motor control techniques while also figuring out how likely it was that someone would get hurt. From the bottom up or from the top down, they can figure out the joint moment. Force plates are used to record ground reaction forces (GRF), and an optoelectronic system is used to figure out how parts of the body move. The top-down method, which is less common, only needs an optoelectronic device to get whole-body kinematics. Because they couldn't be used for more than a few joints, both methods for computing joint moments were not very useful. Because there is so much demand for force plates outside of the lab, it is hard to use a bottom-up approach. There are more restrictions with the top-down method than with the bottom-up method. It has a bigger impact on things like skin artefacts and mistakes in body segment characteristics, for example, when they work from the top down. Using kinematic-based characteristics and machine learning, researchers were able to predict joint moments outside of the biomechanics lab. This allowed them to measure joint moments in the field. The lack of skill and experience in this field means that anatomical landmarks aren't shown correctly and non-representative anatomical coordinate systems are used, which both make it hard to report correct joint kinematics and kinetics. [2]

## 2.0 LOWER LIMBS

Participation in daily tasks requires that a person be able to keep and control their dynamic equilibrium. Fear of falling is linked to less exercise, hopelessness, and anxiety in the elderly, according to a study. Dynamic balance is kept passively in the sagittal plane. Active control is needed to keep balance in the frontal plane, which is mostly done by controlling the placement of the feet. The position of the feet, which can be used to check dynamic balance, is important because it affects how the whole body moves. People can move their feet in the frontal plane, which changes the mediolateral (ML) and vertical moment arms, which are the ways ground reaction forces (GRFs) make an outside moment based on the rate of change in angular momentum over time. People's angular momentum in the frontal plane is tightly controlled when they stand on one leg in single leg stance. When they walk, it has a wider range and isn't as tightly controlled. It all comes down to where a person's feet are, how quickly they move, and how far they can move. In this study, we looked at the basic biomechanical variables that drive dynamic equilibrium, such as ground reaction forces (GRFs) and body segment motion. The position of the ML foot could change, which could make people with mobility problems fall over. People who have no mobility problems, on the other hand, can move their feet in order to keep their balance. Balance problems can be predicted with a variety of techniques, such as the lateral ankle technique, which moves the centre of pressure quickly to correct small mistakes in foot placement. Other techniques can also be used to predict when and how bad a balance problem will be (COP). The lateral ankle technique quickly moves the centre of pressure away from the feet so that minor foot placement issues can be quickly fixed (COP). When there was a visual disturbance, the fastest thing to do was to change the COP. After the disturbance, they can change their foot placement on the next step. With lower-limb amputations, people who use passive prosthetics aren't able to make active ankle moments, which would let them change their COP shift in response to changes in foot position. Following a problem with their foot placement, many amputees use a hip technique to control their GRFs and keep their balance when they are in a single-leg posture. This technique is called the hip method. People use the hip technique to keep their balance if they can't use a COP shift. Participants used a lateral ankle approach to lengthen the ML moment arm and a hip abduction technique to reduce the external moment caused by the ML GRF on the side of the body that was hurt. The heart rate, on either hand, slowed down because the feet were moved to the side. As we said before, better clinical balance scores have been linked to lower heart rate values, and the wider base of support provided by the lateral disturbance did not appear to be a balance risk in this case. To keep the net H at zero during the gait cycle, it was important to change with changes in rotational momentum. This is why The placement of the feet and the use of existing ground reaction forces are used to change the angular momentum. In contrast, walking in a straight line only changes ground reaction force impulses and joint kinetics a little. When the body moves its centre of mass (COM) over the course of a curve, both must change significantly. These people might already have trouble walking in a straight line because their balance and motor skills have changed. [7,23]

## 3.0 FOOT PLACEMENT

Participation in daily tasks requires that a person be able to keep and control their dynamic equilibrium. Fear of falling is linked to less exercise, hopelessness, and anxiety in the elderly, according to a study. Dynamic balance is kept passively in the sagittal plane. Active control is needed to keep balance in the frontal plane, which is mostly done by controlling the placement of the feet. The position of the feet, which can be used to check dynamic balance, is important because it affects how the whole body moves. People can move their feet in the frontal plane, which changes the mediolateral (ML) and vertical moment arms, which are the ways ground reaction forces (GRFs) make an outside moment based on the rate of change in angular momentum over time. People's angular momentum in the frontal plane is tightly controlled when they stand on one leg in single leg stance. When they walk, it has a wider range and isn't as tightly controlled. It all comes down to where a person's feet are, how quickly they move, and how far they can move. In this study, we looked at the basic biomechanical variables that drive dynamic equilibrium, such as ground reaction forces (GRFs) and body segment motion. The position of the ML foot could change, which could make people with mobility problems fall over. People who have no mobility problems, on the other hand, can move their feet in order to keep their balance. Balance problems can be predicted with a variety of techniques, such as the lateral ankle technique, which moves the centre of pressure quickly to correct small mistakes in foot placement. Other techniques can also be used to predict when and how bad a balance problem will be (COP). The lateral ankle technique quickly moves the centre of pressure away from the feet so that minor foot placement issues can be quickly fixed (COP). When there was a visual disturbance, the fastest thing to do was to change the COP. Following the disruption, a person can adjust their foot placement on the following step. With lower-limb amputations, people who use passive prosthetics aren't able to make active ankle moments, which would let them change their COP shift in response to changes in foot position. Following a problem with their foot placement, many amputees use a hip technique to control their GRFs and keep their balance when they are in a single-leg posture. This technique is called the hip method. People use the hip technique to keep their balance if they can't use a COP shift. Participants used a lateral ankle approach to lengthen the ML moment arm and a hip abduction technique to reduce the external moment caused by the ML GRF on the side of the body that was hurt. The heart rate, on either hand, slowed down because the feet were moved to the side. As we said before, better clinical balance scores have been linked to lower heart rate values, and the wider base of support provided by the lateral disturbance did not appear to be a balance risk in this case. To keep the net H at zero during the gait cycle, it was important to change with changes in rotational momentum. This is why The placement of the feet and the use of existing ground reaction forces are used to change the angular momentum. In contrast, walking in a straight line only changes ground reaction force impulses and joint kinetics a little. When the body moves its centre of mass (COM) over the course of a curve, both must change significantly. These people might already have trouble walking in a straight line because their balance and motor skills have changed. [7,23]

## 4.0 LENS CAPSULE

As the lens capsule of the eye moulds the fibres that make up the lens, the light is focused on the retina in the correct way. The lens capsule of an eye protects the lens fibres for the rest of their lives. Presbyopia is caused by the lens becoming more rigid and the ciliary muscle moving forward as we get older. Both of these things are important. The majority of people can no longer adapt by the time they are 55. [9] In the National Eye Institute, this is when cataracts become more common. By the time a person is 75, more than 70% of people have them, and that number keeps rising until it's more than 90%. People get older, and their lens fibres start to break down. They need to use a prosthetic intraocular lens (IOL), which is inserted into the remaining lens capsule during cataract surgery to fix their vision. [10] This job is done by the ciliary muscle, which is near the eyeball. In its relaxed state, the ciliary muscle exerts a gravitational force on the lens's equator through zonules, which are fibrillin-based guidewires that connect the ciliary muscle to the lens. In this case, the lens is out of place (far vision). When the muscle relaxes, the zonules and strain energy in the lens capsule are released, allowing the capsule to shape the underlying lens fibres toward a more quasi-sphere shape (near vision) [11] In order to learn more about how the lens capsule moves after cataract surgery, only a small amount of modelling has been done. Given that cataract surgery is the most important medical use of lens capsule mechanics and the most common ocular surgery, this is a surprising conclusion. Over 3 million cataract surgeries are done in the United States alone each year. There were more circumferential and meridional stiffness as the anisotropy level went from the poles to the centre, but the meridional stiffness went down. This is how the Fung strain energy function came to be used to make biaxial mechanical parameters for a membrane (2-D) hyperelastic constitutive model based on the data from the experiment. The calibrated Holzapfel model is very good at fitting the data, which is similar to data from inflation and uniaxial mechanical tests. Both the Holzapfel hyperelastic constitutive model to regional variations in anisotropy and the Holzapfel hyperelastic constitutive model to regional variations in anisotropy have been used in order to make fully 3-D models of the lens capsules before and after surgery (between elements along the meridional direction). A method called Holzapfel was used because it had been used before for collagenous soft tissue (arteries) (arteries). It was made for collagenous soft tissue. It has physiologically relevant characteristics that can be changed to make uniaxial and biaxial mechanical data fit better (arteries). [10]

## 5.0 FEMORAL CONDYLE

Spending a lot of time looking at a contact route on the femoral condyles could help some people see how the knee moves in real time. If only the articular contact points on the femoral condyle surfaces were moving, that would be very useful. Asymmetric articular contact motions of a femoral condyle during knee flexion could be an example of the femur's physiological motion characteristics. These motions could be different from the translations of the anatomical femoral condyle axis, which could be because the femur's physiological motion characteristics are different. The findings used both morphological and physiological techniques to look at the knee's kinematics. As a result of the findings, several theories about how the axial femoral condyle rotates were made. This means that due to greater posterior translational values of the lateral femoral condyle, which suggests a medial pivot-axis rotation of the femoral condyle, there are greater distances between articular contact points on the medial side of the femoral condyle than on the lateral side (that also suggests a medial pivot-axial rotation of the femoral condyle) A tibial plane was used to look at anteroposterior and axial rotations of the femur in most recent studies. The trans-epicondyle (TEA) and geometric centre axis (GCA) were used for this. Recognizing this is very important for the development of current surgical techniques, which try to get patients back to normal knee kinematics as soon as possible. A group of researchers studied the relationship between how the femoral condyle moves and how the knee articular contact kinematics move in the tibial plane. They found that morphological motion descriptions couldn't accurately represent how the kinematics of the knee joints move in the tibial plane. When the knee is bent, the femoral condyle outside the joint showed outside axial rotations. People started thinking about how a knee can pivot in an axial direction because the way the morphological technique looked at it, the lateral femoral condyle could move further back than the medial femoral condyle could. [12] This has been shown to be true in a number of studies. The asymmetrical shape has been linked to big changes in axial external rotations of the bone at low flexion degrees. The concave medial surface of the tibia, for example, was thought to keep the medial condyle from moving during knee flexion, which caused the femoral condyle to pivot in the opposite direction. [23]

## 6.0 MUSCLE ACTIVATION

Using musculoskeletal models and computer simulations, it is possible to look at how muscles work and how they interact with each other without having to do any therapy. Using hand models, students may be able to better understand how a hand's strength, precision movement, and dexterity are used in their daily lives. [13] We know that when we do dynamic tasks, our lower bodies are put under a lot of stress, but how this affects the distribution of that stress isn't clear yet. Researching the function of deep hip muscles takes a long time because of the unique nature of the hips. During experiments, deep hip muscles have been found to be activated in specific ways. This information, combined with neuromusculoskeletal modelling techniques, can be used to get a sense of how these muscles influence the direction of hip loading during a dynamic task. Neuromusculoskeletal modelling can be used to study deep hip muscle activity. This modelling can be used to recreate different levels of muscle activation. [14] During both walking and squatting, the centre of hip loading started to move toward the acetabular centre as a result of computationally impositioning maximal activation of deep hip muscles, which moved the centre of acetabular loading toward the centre. [14] During a variety of tasks, electromyography (EMG) signals show up in certain patterns. These patterns show up when people are anticipating a transition and when they have individual, antagonistic, and cooperative muscular roles. To help with the development of targeted rehabilitation methods and the improvement of robotic control, patient-specific simulations have been used. This is because these patterns can help with the development of future treatment and rehabilitation that is tailored to a specific type or severity of a curve. [1] When there is a disruption, intrinsic muscle stiffness is the first thing to look for to protect oneself. Actin and myosin contact grows as the number of actin and myosin interactions rises. It also grows as the level of muscle activity rises, or even the amount of actin and myosin contacts available at the time of disruption. Milliseconds are used to figure out how stiff a muscle is inside. [15] Muscle stiffness protects the joint by reducing the amount of excessive joint translations and ligament strain that can happen as a result of an accident outside of the body. However, even though this could show how neural-based mediating effects on age-related changes in joint effort could be explained by this, the relationship between muscle activation and mechanical joint work during walking has still not been studied. Older people have more agonist muscle activation and antagonist muscle co-activation when they walk than younger people. A person in their 50s or 60s may be able to do more work with their joints than a person in their 20s or 30s. It's expected to make joints more stable by making them more stiff, but it will also require more agonist activation to get the same amount of work done, according to the research. Next, the researchers found that when people walk on a flat surface and when they walk on an incline, their muscles work more. This makes walking more difficult as we get older. Older people are more likely to have higher electromechanical costs than younger people, but only for positive joint work while walking uphill and not for negative joint work while walking downhill, as previous research has shown. It didn't matter that age didn't influence the relationship between muscle activation and negative work for the Knee Extension (KE) in younger people. In older people, the relationship wasn't statistically significant. More research is needed to find out if the rise in active and passive muscle stiffness seen by others has a big effect on how much work people don't do. Even though shortening muscle contractions are more common as they go up, lengthening muscle contractions require less muscle activation per unit of muscular force because they rely mostly on passive forces generated by series elastic components to work. [16] This is because of the length of the muscles. This means that muscular force is usually made without the muscles working. Edge loading can be less likely to happen when deep hip muscles aren't working hard enough. This is because these muscles have the most power to cause edge loading when deep hip flexion is done. [14]

## 7.0 COLLAGEN FIBER

There are three layers to a healthy artery, and they can be seen from the surrounding cells. Endothelial cells, a thin basal membrane, and a subendothelium layer make up the intima. The media (middle layer) is made up of a 3D network of elastin, smooth muscle cells, and collagen fibres, and the adventitia (outermost layer) is made up of fibroblasts, fibrocytes, a ground matrix, and dense bundles of collagen fibres, as well. Because the artery wall is not a single piece of material, the best way to model it is to use a multi-layer structure model that includes both its design and its many layers (intima, media, and adventitia). [13] In arterial tissue, collagen fibres are spread out much more than in other tissues. [17] The whole artery and medium samples have more anisotropy than the intima and adventitia samples. They also have a higher anisotropic index than the intima and adventitia samples. According to the intima, the collagen fibres' organisation is to blame for the decreased anisotropy. [18] According to some theories, the perineurium's layers and the presence of collagen fibres make it strong. It takes more force to break through the membrane and break the structural integrity of these densely packed layers of lipids. The shape of the epineurium helps nerve fibres move and shift in response to stretching and contracting nerves, which would be needed for healthy nervous system function. [19] Temporomandibular Joint (TMJ) cartilage has a complex structure-mechanics relationship that must be understood in order to come up with effective treatment options. Based on the structure of the cartilage, TMJ cartilage is broken down into four zones. TMJ cartilage is different from other types of hyaline cartilage because it has a surface layer made up of type I collagen fibres that are perfectly aligned. By absorbing the shear stresses that happen when the jaw moves, this fibrocartilage surface layer protects the joint from high loads when we eat. [20] The oesophagus is a tube-shaped organ that has three layers: the submucosa, the mucosa, and an outer layer of muscle on the outside. In this picture, the submucosa layer is below the mucosa layer. The mucosa layer is below the mucosa layer. Due to its size, the submucosa is responsible for the structure of the tissue, which makes up a big part of its mechanical stiffness. It also has a lot of collagen fibres and significant amounts of water in it. Stents that can self-expand are used to open up the obstruction caused by cancer-related in the oesophagus as a main palliative therapy to lessen the symptoms of dysphagia, which can make it hard to eat and drink. When this treatment is done, the shape of the oesophagus goes above and beyond normal. This leads to more research into how tissue is damaged. [17]

## 8.0 KNEE JOINT

Total knee arthroplasty (TKA) is a procedure that is used to help people who have had problems with their knees for a long time, like osteoarthritis. According to the National Joint Registry of the United Kingdom in 2021, more than 30% of patients who have single-stage revision surgery end up with aseptic loosening. One of the problems that can happen after TKA is that the peri-prosthetic bone may not be able to handle the stress. It is one of the things that could put TKA's long-term survival in danger. As a result of TKA, stress shielding happens, which can cause bone stock loss around the knee implant. This can cause the implant to come loose as a result. [21] Those who had anterior cruciate ligament surgery (ACL) had better anti-phasing coordination in the DDT side-cut method than those who didn't have surgery. This means that their knees played a bigger role than their hips did. The DDT change score made it easier for the research patients to move their knees adduct than for the control group to move their hips flexion-extension. Following surgery on the ACL, the focus on keeping the knee joint stable can move closer to the hip. This means that the hip is a critical stabiliser for side-cut mechanics in early and mid-stance. There could be a number of reasons for this. One possibility is that it's an attempt to make up for knee restrictions by increasing hip freedom. [22] In this study, a dual fluoroscopic imaging system (DFIS) was used to look at knee joint mobility during a quasi-static single leg lunge. In addition, the 3D-2D registration method was used to match the projection of a three-dimensional knee model to two fluoroscopic images taken along the flexion path. This way, a virtual dual fluoroscopic imaging system could be built (DFIS). To figure out how the TEE condyles move, the lateral and medial epicondyles were joined together along the trans-epicondyle axis, as shown in the diagram below (TEA). There were two places where the TEA and two GCA planes crossed. These places were used to figure out the condylar motion of a TEA condylar axis. A tibia-knee joint coordinate system was made and tested to make it easier to measure the angle of flexion and the movement of the morphological condyles in the knee joint. [23] So that we could get the best information out of our data for the hips and legs as well as the feet, a certain amount of time in the stance phase was chosen. To show how the hip flexed at the first contact and then extended at the end of the stance, the hip joint was thought of as being 100% of the length of the stance. Because the hamstrings work all the time in both early and late stance, the one hundred percent of stance was looked at. The angles of the knee joints at 0 and 50% of stance were looked at because there was evidence that the knees were moving in an unusual way and that the hamstrings were working in an unusual way at the end of the swing. Ankle joint angles at 50% to 100% stance were chosen after weighing many different options. This will help us learn more about how to move the ankles from full dorsiflexion to active plantarflexion, which is done with calf muscles. [24] Based on local Coordinate system definitions, loads are applied to the joint in vitro. Local Coordinate systems also affect how the joint moves in real life (LCS). It affects both the kinematic description of how joints move and how the joints move in real life because of Local Coordinate Systems (LCS). A possible benefit of using anatomical Coordinate systems (ACS) is that they can measure kinematic aspects that may not be present with objective Coordinate systems (CS). This includes the screw-home mechanism of the knee joint, which is when the tibia rotates inward as the knee bends early (CS). [25]

## 9.0 WALKING SPEED

Motion capture has been an important part of biomechanics research and instruction since the late 1800s, when Eadweard Muybridge and Etienne-Jules Marey came up with a way to record human movement with cameras. Motion capture technology has been getting better and better as it has been used more and more in the industry. It uses skeletal modelling software and data from outside forces to figure out joint kinematics (angular orientations, velocities, and accelerations) and kinetics (moments and powers). This technology has been used by many researchers to figure out how people move in a variety of ways and across different types of terrain. For example, it can show how fast people walk, how steep a ramp is, and how high a stair is. Ascending and descending stairs and ramps haven't been getting as much attention recently. [1] There is more and more evidence that people who have ankle osteoarthritis have a lot of damage to their feet and lower legs because of how they move. They took smaller steps and walked slower than a group of people who didn't do this. They also didn't move their ankle joints as much as the control group did. Comparing distal foot joint data from patients with ankle osteoarthritis to healthy data when walking in three-dimensional (3D) models, researchers found that patients with ankle osteoarthritis use compensatory strategies when walking in distal foot joints. Discrepancies in joint range of motion should be taken with a grain of salt because walking speed has an effect on the way the feet move. In the pre-swing phase, foot joint motion in the sagittal plane is very important, and walking speed has a big impact on this motion. This is shown by less motion at slower walking speeds. During pre-swing, the metatarsus-hallux joint was the only part of the foot that was affected by the speed of walking before and after surgery. [4] People who can walk better and are more independent, and who have a better quality of life, can set their own walking speed. This is especially true for the elderly and people who have neuro-musculoskeletal disorders, like cerebral palsy or a stroke, who need help moving their bodies. After having a stroke, hemiparesis can have a lot of negative effects, such as irregular gait patterns and a slowing down of walking speed. After a stroke, gait therapy can help walking faster, which is the goal of the treatment. [26] Walking speed, on the other hand, is a complicated mix of walking mechanics that affects one's ability to move forward. [27] Gait training paradigms are now being used to help people who have had a stroke increase the amount of force they use to walk faster. [26] To keep the benefits of treadmill training while still allowing for some variation in stride-to-stride speed, researchers have used adaptive, user-driven, or self-paced treadmills that change the speed of the belt quickly when the user tells them to. According to a lot of research, many studies used adaptive treadmill control algorithms that were mostly concerned with the user's position on a treadmill or the user's spatiotemporal characteristics. However, most of these studies didn't look at the relationship between propulsion and walking speed. Adaptive treadmill control systems have been used in a lot of studies that only looked at where the user was on the treadmill or how long it took them to walk. In most of these studies, the relationship between propulsion and walking speed was successfully ignored in order to maximise efficiency. [26]

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