

RQ: To What Extent Do Principles Of Physics Explain Precise Parkour Landings And What Are The Physiological And Psychological Benefits Of Parkour?

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Abstract

Parkour is increasingly being recognised as a unique, non-traditional sport which requires practitioners to execute complex movements to overcome challenges. This research paper particularly looks at landings, such as precision landings, roll landings and kong vault landings among others, in parkour and analyses how the foundation of their execution lies in laws and principles derived from the field of Physics. The latter half of the paper also evaluates the physiological and psychological benefits of practising parkour specifically for the youth.

Key Words: *Parkour, Physics, Physiological health, Psychological health*

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I. Introduction

Do you know how it feels to defy gravity? Freely move around where the world is your playground and obstacles are new opportunities.

Art du déplacement (Egger, 2023) or Parkour developed as a French discipline in the late 1980s and gained popularity all over the world through various action movies. Eventually developed as a part of military training, it came on to being recognised as a sport, first, by Britain in 2016 (Bauer, 2018). Parkour is something that can be done anywhere at any time by anyone regardless of their age, if a person is willing to put in the time and effort. One of the most prominent groups of traceurs was the Yamakasi who helped make parkour much more prominent in today's age where people are barely able to take time to move around due to monotonous work routines. Looking at how Parkour has been accepted around the world, soon enough Parkour will take over as the "new" thing in people's lives (Cyr, 2024).

A unique and unorthodox sport, Parkour is a discipline free from stringent rules allowing the athlete to adapt to the environment and push their limits to understand what the human body is capable of. Adapting to the environment is an extremely critical part of Parkour as the traceur has to be one with the obstacles, efficiently land and get past them. Parkour practitioners have been found to traverse through obstacles with optimal energy management and can distribute the forces evenly throughout the body when they land without interrupting their flow (Pagnon et al., 2022). Such techniques leave one to ponder about the physiological characteristics of a parkour athlete and the physics behind the complex art of landing which is one of the most important components of any parkour movement. In line with the aforementioned, this research paper aims to answer the question: **To what extent do principles of physics explain precise parkour landings and what are the physiological and psychological benefits of parkour?**

This paper aims to analyse various parkour landings which will then be evaluated with the help of physics principles and theories to understand how the traceurs are able to effortlessly navigate through obstacles and master the art of landing. Moreover, the paper also aims to analyse the physiological and psychological benefits of practising parkour.

II. An In-depth Review of Parkour Landings

With Parkour being such a dynamic sport without strict limitations, it allows the traceurs and traceuses to channel their creativity. One essential component of Parkour is the art of landing, without which no movement is complete. The ability to distribute forces all over the body to make a smooth landing is what makes it an art (Adams, 2020). There are several parkour landings which will be discussed in this section including Precision Landings, Roll Landings, Cat Landings, Safety Landings, Kong Vault Landings and Lazy Vault Landings, all used to minimise impact and maximise the efficiency of the movement.

Precision Landings



One of the most common landings practised by Parkour athletes is Precision Landings. Precision jumps are those which require utmost accuracy to land on thin edges, lines or platforms while efficiently balancing and distributing all the forces acting on you so you don't fall. One of the major things which allows traceurs

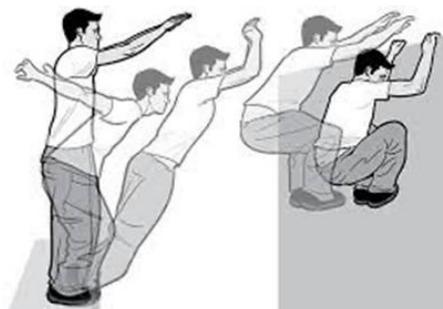
to perform these Precision Landings is their ability to prolong the landing phase duration as it allows the forces to distribute evenly (Maldonado, Soueres and Watier, 2018). To do this, Parkour athletes usually land on the ball of their feet and maintain a low position which also lowers their centre of gravity and increases their stability (Musholt, 2013b). Precision landings are extremely essential as they help the Parkour athlete increase their spatial awareness by allowing them to interact with the environment swiftly and help practise their balance as they land on narrow spots with tight margins of error.

Roll Landings



A landing performed by Parkour athletes very often, Roll landing, is a method of reducing the momentum of the athlete by efficiently decelerating them while still allowing them to keep moving forward. Additionally, such a landing can also help the athlete recover if they have stumbled while performing a jump or vault among other movements. The Roll Landing is very easy and efficient if performed the right way, which is by rolling over your shoulder and transferring body weight over to your legs to allow you to get up quickly and continue with the run. Rolling over your shoulder lets the force be distributed over muscle-padded areas of your shoulder and back instead of critical joints such as your wrist and ankle (Musholt, 2013a). Such a Roll Landing proficiently allows you to transfer the landing force into forward force for further movements.

Cat Landings



Another type of Landing, different from the conventional ones is the Cat Landing, also known as the Cat Leap. From the name itself, this landing is similar to how cats go from one wall to another and mimics how cats too are natural parkour athletes with their ability to perform complex movements while simultaneously

adapting to the environment. The aspect of this landing which makes it different from regular landings is the athlete's position as they are

upright instead of being on the ground. The traceur/traceuse jumps towards a wall, grabs it from their hands and uses their feet as support, using the feet to push themselves away from the wall to prevent banging into it. Placing your feet on the wall first helps dissipate the force at which you approach the wall allowing a soft landing (StormFreerun, 2018).

Kong Vault Landings



The Kong or King Kong Vault is another landing which helps the athlete dissipate their energy and force to the surroundings as they use their legs to thrust their body in the air and hands to support themselves as they hover over the obstacle. The athlete throws themselves over the obstacle and use their hands to further push their body forward to clear the obstacle and safely land. Being one of the most common movements performed by parkour practitioners, it is quite complex as the athlete always has a fear while thrusting the body forward, and to overcome such a fear, it is always recommended that you practise with progressions slowly and once fully confident, commit to the vault and complete it with finesse (Coops, 2023a)

Lazy Vault Landings



Now coming to the last of the landings and vaults is the Lazy Vault. Just like the Kong vault, the athlete transfers their weight throughout the body and throws their legs forward which guides their body towards the desired direction. The vault involves a long contact time with the obstacles allowing the athlete to adjust their balance and increase their spatial awareness while

traversing through the current obstacle itself. This vault is executed smoothly with fluidity as the practitioner rotates approximately 45 degrees which contributes to rotational momentum allowing them to move over to the next obstacle with ease. This is a relatively simple movement which can be learnt easily by beginners as what one mainly needs to do is throw themselves forward, support their body and then gravity will do the rest (Coops, 2023b).

III. Principles Of Physics Applied To Parkour Landings

The movements in Parkour can be explained using various laws of Physics. The dynamic nature of this sport is what makes it interesting for physicists as traceurs make use of different physics concepts to efficiently land and move from one spot to another. Physics plays an integral part in parkour as it helps the traceurs perfect flips, rolls, jumps and landings. This section analyses different principles, laws and theories being applied to various types of parkour landings, including how the principle of the conservation of energy applies to different landings, the role of the control of the centre of mass of a traceur for precision landings, the rotational mechanics for roll landings, distribution of forces in cat and safety landings, and the role of energy transfer in the kong and lazy vault.

Conservation of Energy Across all Landings

The principle of the conservation of energy simply states that energy cannot be created or destroyed but can only be transferred from one energy store to another in an isolated system. An energy store here is a place where energy is stored (Khan Academy, 2016). To further explain this concept, we can use the example of a dropping object. As an object drops from a height, its gravitational potential energy converts into kinetic energy and all energy is conserved and not destroyed as the energy is transferred from one store to another.

As we apply this concept to parkour landings, we can understand how traceurs are able to conserve their energy and maintain a smooth flow of movement. Roll landings, for example, help the parkour athlete conserve momentum and allow them to make a smooth transition as energy is transferred from one store to another instead of the surroundings, so a minimal amount of energy is wasted. In roll landings, the energy is not only transferred forward but downwards as well since the force exerted by the athlete is acting in two directions, in front of them and under them. The force exerted in the forward direction allows the athlete to advance forward while the force exerted in the downward direction helps transfer the force into the ground since the body is lowered which helps reduce the overall impact on the athlete's body after the roll allowing them to smoothly transition to the next obstacle (Learning to be Silent, 2009).

Center of Mass Control for Precision Landings

The centre of mass or centre of gravity is a vital concept to know about if you are a parkour athlete. The centre of mass is the point at which gravity acts on a body. The centre of mass of a body can be changed which allows a traceur to perform impressive feats. The centre of mass is extremely important to know about in parkour since it affects your balance and stability. The higher the centre of mass, the more difficult it is to balance. This is one of the reasons why traceurs keep low when they try to land on small platforms (Sinicki, 2015).

As an application of this concept in the world of parkour, we can look at precision landings. Traceurs tend to get into a low squatting position as they perform this landing which brings their centre of mass down making them more stable on thinner surfaces like rods and ledges. As one performs a precision jump, one often has to adjust their body to balance and stabilise oneself constantly. To have a smooth flow of movement, a traceur has to compromise between speed and stability, this is because the centre of mass has to be high for a fast speed but the centre of mass has to be low for balance. The compromised centre of mass here should approximately be close to the centre of the body so that the parkour athlete can be both agile and balanced at the same time (Sinicki, 2015).

Rotational Mechanisms for Roll Landings

Rotational motion can be defined as the motion of an object in a fixed, circular orbit. This concept can easily be explained with the example of a ceiling fan. A ceiling fan has blades which show that the fan has a constant radius, and the fact that the fan rotates on a fixed point explains that it has rotational motion since it is moving in a fixed, circular orbit. Factors which affect rotational motion include the magnitude of the force, the direction of the force and the axis of rotation (BYJUS, 2016). A parkour practitioner keeps all of these factors in mind as they roll as they affect the outcome of the landing.

The application of this concept in parkour can be seen as a traceur performs a roll landing. As one rolls forward, the linear momentum turns into angular momentum which leads to a quicker rotational motion and decreased impact on any single part of the body as the force is distributed over the ground. The axis of the practitioner as they rotate plays a big role as well since it affects their balance and stability during the roll (BYJUS, 2016). The conservation of the angular momentum is what allows for a smooth and efficient roll landing since the magnitude of the force is also conserved which eventually allows the traceur to stand back up after the roll.

Distribution of Forces in Cat Landings

As parkour athletes jump from one spot to another and land, a large amount of impact force is generated which applies stress to their joints. By landing carefully, the impact force can be reduced and distributed over a larger area so that as much stress is not applied to the traceur's joints. Ground reaction forces (GRF) play a big role in the distribution of forces as this is what impacts the athlete the most. Too high of a GRF can impact the musculoskeletal system greatly which increases the probability of injury. It is important for athletes to carefully land and distribute forces, in order to have a smooth transition over to the next obstacle and reduce the risk of injuring themselves.

We can discuss the distribution of forces in the field of parkour through cat landings. As a traceur jumps from a platform to a wall, they throw their hand to the top of the wall to grab it and use their feet to create a distance between them and the wall. Using hands to grab onto the wall reduces the impact on the legs making it easier for the traceur to land. Distributing the impact force in such a manner is not only efficient but safe for

the traceur as well since a lesser amount of force is concentrated on a single joint which reduces the overall risk of injury. The nature of cat landings allows for soft landings which lead to a much smoother transition to the next obstacle as the traceur does not have to recover from a large impact force on their legs after landing (Puddle and Maulder, 2013).

Energy Transfer and Conservation of Angular Momentum in Kong and Lazy Vault Landings

For smooth and efficient movement, a parkour athlete must transfer energy from one store to another efficiently. As energy can neither be created nor destroyed, it is transferred from one form to another. As discussed previously as well, using the dropping object (gravitational potential energy → kinetic energy) example, energy is transferred between stores which means that it is not created or destroyed but transferred to another energy store (Gregersen, 2022). The conservation of angular momentum basically means that an object will continue spinning as it was unless an external torque acts on it. We can use the example of a spinning ice skater to further explain this concept as when the ice skater extends their hands or pulls them back inwards, a change in their velocity occurs. As no external force or torque acts on the skater, their angular momentum is conserved as her velocity increases (BYJUS, 2022).

The application of energy transfer in parkour can be seen in kong vaults. As the traceur throws their body forward and pushes their weight upward using their hands to gain height, energy is transferred through numerous stores. First, it is transferred from the kinetic energy store to the gravitational potential energy store as the athlete runs and jumps towards the obstacle. Then the gravitational potential energy is converted back into kinetic energy after the athlete uses their hands to push off the box and move forward with the thrust generated using their hands (Adams, 2021). The principle of the conservation of angular momentum can then be applied to the lazy vault. Since the traceur has to rotate their body approximately 90 degrees to bring their legs forward, angular momentum comes into play here. The traceur must be careful as both under-rotating and over-rotating can result in falling and injury. The conservation of angular momentum comes into play as an external torque can result in the traceur losing balance, so the angular momentum must stay constant throughout the movement phase so that the athlete can execute the lazy vault efficiently without injuring themselves.

IV. The Physiological And Psychological Benefits Of Parkour

A lot of research exists on the mental and physical benefits of regular exercise. More specifically, it has been greatly suggested that physical activity should be promoted to the youth so that it can become a component of their lives that is practised into the later years as well. In line with this, Parkour presents an attractive choice among the youth as it is somewhat a non-traditional sport wherein no rules and restrictions apply but instead, creativity and going with the flow are condoned. Interestingly, there are also many physiological and psychological benefits of practising parkour. From a physiological perspective, parkour provides a full-body workout as it engages several muscle groups. With constant jumping, climbing and running, parkour helps improve the overall strength and endurance of a practitioner. Furthermore, as Parkour requires movements from one obstacle to another, it also promotes balance and coordination in practitioners. Parkour also has great cardiorespiratory benefits. A study by Dvorak et al. (2017), for instance, found that “parkour intervention had a beneficial effect on VO₂peak, VO₂ 10km/h and anaerobic threshold demonstrating that parkour training is an effective training stimulus for improving cardiorespiratory fitness in children aged 16 ± 2 years”. From a health perspective, this finding is useful as an increase in peak oxygen concentration and a consequent increase in cardiorespiratory fitness can prolong the development of cardiovascular disease in adolescents (Circulation, 2007).

Furthermore, parkour can also have many advantages for mental health. One of the main benefits stems from the community/social aspect of Parkour. Parkour is a sport which can be practised with other people and within groups. When an individual surrounds themselves with those who share similar interests and are keen to see them succeed in the sport then this can truly uplift the mood of a practitioner. Another mental health benefit of parkour for the youth specifically is that it provides mental rest. Whilst some other exercises including kickboxing make practitioners partake in slightly more aggressive methods of releasing their stress, parkour provides an alternative wherein practitioners can vent more constructively and creatively. Finally, parkour is a challenging sport with the challenges and obstacles progressively increasing. By giving individuals the chance to achieve something new or overcome a new obstacle each they practise, Parkour provides constant rewards for the successes that one is able to achieve. This can once again be greatly beneficial to the mental health of the youth, specifically those who have been feeling defeated and out of control (Parham, 2021).

V. Conclusion

Complex theories, concepts, and principles of physics can be applied to the intricate art of parkour landings to understand how to execute them efficiently and precisely. In addition to the physics-driven aspect of landings, parkour also offers psychological and physiological benefits to a traceur. In line with the aforementioned, this paper aimed to analyse the application of physics theories, concepts and principles to parkour landings alongside the psychological and physiological benefits of practising parkour.

As explored in this paper, there are a number of parkour landings, each different in its own way and each analysed in the context of a specific physics concept or law. Precision landings, for instance, require utmost accuracy and are usually utilized when athletes try to land on thin surfaces where one needs to balance, so the centre of mass control plays a vital role here as the athlete needs to stabilize themselves. Moreover, as discussed, roll landings are used to help athletes maintain a smooth flow of movement and reduce the impact on their joints as they land as roll landings make use of rotational mechanisms. Additionally, kong vault landings involve a dynamic forward leap as the athlete uses their hands to thrust themselves forward while lazy vault landings on the other hand involve using one hand to have a fluid sideways motion so energy is transferred and angular momentum is conserved which allows the athlete to maintain a smooth flow of movement. This is evidence that physics principles explain precise parkour landings to a great extent.

Parkour has many psychological and physiological benefits as discussed in this paper. Due to the explosive nature of parkour movements such as jumps, vaults and landings, muscle strength is built in practitioners. Balance, coordination, flexibility and agility are positively affected by parkour as well since they affect the parkour athlete's ability to stick landings in difficult terrains. Furthermore, cardiorespiratory endurance is increased by practising parkour due to the dynamic movements as an efficient cardiovascular system aids in managing energy levels in an extended training sequence.

This is beneficial in prolonging and preventing cardiovascular disease. Beyond the physiological, the psychological benefits of practising parkour lie in greater mental toughness, a sense of belonging to a community and an outlet to creatively release any stress.

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