Effects of Functional Movement Skills on Parkour Speed-Run Performance

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Funding Details

No sources of funding from any funding agency in the public, commercial, or not for profit sectors were used to assist in the preparation of this article.

Disclosure Statement

The authors declare that they have no competing interests.

As accepted for publication in European Journal of Sport Science, Taylor & Francis, Online

Abstract

Parkour speed-runs require performers (known as Traceurs) to negotiate obstacles with divergent properties such as angles, inclinations, sizes, surfaces, and textures in the quickest way possible. The quicker the run, the higher the performer is ranked. Performance in Parkour speed-runs may be regulated through Parkour Traceurs' functional movement skill capacities given the physical requirements of the event. This study examined what functional movement skills correlate with Parkour speed-run performance. Nineteen male Parkour Traceurs undertook a physical testing battery inclusive of: agility T-test, maximal grip strength test, and maximal vertical and horizontal jumps across several jump modalities. For the speed-run, Parkour Traceurs navigated an indoor Parkour installation. Pearson's correlation analyses (*r)* revealed that agility T-test performance showed a positive correlation with Parkour speed-run performance, whereas standing long jump and counter movement jump (with and without arm swing) were significantly negatively correlated with Parkour speed-run performance. Concurrent with the intrinsically-linked building blocks in the Athletic Skills Model, the data from the present study suggest that performance in Parkour-speed-runs are underpinned by functional movement skills (jumping, running; arm swinging) and conditions of movement (agility), all of which encapsulate elements of basic motor properties (speed; strength). From a practical perspective, the agility T-test, standing long jump, and counter movement jump with and without arm swing can form a basic battery to evaluate the physical effects of Parkour speed-run interventions on functional movement skills.

Introduction

The popularity of Parkour has grown considerably in recent years and it is now practised as a competitive sport. However, its original guiding principles drew motivation from George Hébert's Méthode Naturelle, a training model focused on functional exercises relating to physical conditioning and development of functional movement skills (i.e., walking, climbing, jumping, rising, carrying, running, throwing, attack-defence, and swimming) (Terret, 2010), that underpin execution of complex movements and cultivate a well-rounded athlete (Hébert & Till, 2017). Parkour athletes (known as Traceurs) still emphasise the importance of Parkour for the development of functional movement skills, such as climbing, jumping, running and quadruped movements (Strafford et al., 2020), although these are yet to be substantiated in empirical research. This emphasis on development of functional movement skills shares parallels with practitioner-informed models of athlete development underpinned by the theory of ecological dynamics, notably, the Athletic Skills Model (Wormhoudt et al., 2018; Savelsbergh & Wormhoudt, 2019). The Athletic Skills Model is a concentric, skill-centred approach to athlete development, comprising of three intrinsically-linked building blocks: 10 basic movement skills (referred to thereafter as 'Functional Movement Skills' (Newell, 2020) *(aiming; balance; climbing; jumping; kicking; rolling; romping/fighting; running; swinging; throwing),* Coordinative Abilities *(adaptability; balance; coupling; kinetic differentiating; spatial orientation; rhythmic ability)* and Conditions of Movement *(agility; stability; flexibility; power and endurance),* all of which encapsulate elements of basic motor properties (*coordination; speed; strength; flexibility and endurance)*. The Athletic Skills Model proposes that developing an athlete's functional movement skills will lead to further gains in their coordinative abilities and conditions of movement (Wormhoudt et al., 2018). Activities promoting the acquisition of functional movement skills are considered essential for the physical development of athletes, regardless of specialisation.

When considering the qualities that characterise successful performance in particular tasks, the Athletic Skills Model proposes that the physical requirements of each sport should be appraised against the 10 functional Movement Skills, which are separated into four different classifications using the Athletic Skill Model continuum: sport-specific, sport-adaptive, sport-related, and sport-supporting. Similar to *Méthode Naturelle*, the Athletic Skills Model suggests that functional movement skills are not isolated movements, but rather fundamental motor skills which support the functionally adaptive movements needed in a specific performance environment. Concepts in ecological dynamics predict that adaptive movement behaviours will emerge through a Parkour Traceur's interactions with rich and varied opportunities for action (Chow et al., 2020), (termed *affordances*) in the environment (Gibson, 1979). The coupling of perception and action, which emerges as Traceurs explore their Parkour environment seeking opportunities for action, forms the fundamental basis of skilled behaviour in ecological dynamics, established and refined by developing an athlete's *effectivities* (movement/action capabilities). In the context of athletic development in Parkour, *effectivities* might reside in the functional movement skills outlined in the Athletic Skills Model (Strafford et al., 2020). Over time, as Traceurs are repeatedly exposed to the Parkour environment, this process will lead to the establishment and refinement of acquired perception-action couplings, in particular those underpinning functional movement skills, resulting in improvements in performance by enhancing athlete self-regulation (Strafford et al., 2018). The nature and landscape of Parkour environments offer many available affordances for jumping, landing, and changing direction. Therefore, Traceurs who are repeatedly exposed to such environments have the opportunity to explore and discover solutions to navigate them and so develop these functional movement skills. In turn, it is possible that the best Traceurs may excel in tests of these functional movement skills, although it remains unclear what functional movement skills (if any) correlate with Parkour performance.

The suggestion that functional movement skills could be associated with Parkour performance has to some extent been investigated by Abellan-Aynes and Alacid (2017) who separated Traceurs into high and low performance groups based on judges' scores. The high-performance group significantly outperformed their counterparts in both counter movement and long jump tasks, suggesting that performance on these tests of functional movement skill is associated with Parkour performance. However, the use of subjective judge ratings meant the study failed to employ an objective or validated measure of Parkour performance. Recently, Dvorak, Balas, and Martin (2018) sought to confirm the reliability of a Parkour skills assessment tool, however, it was also reliant on ratings of coaches and so was again limited by subjectivity of interpretation. Most recently, Padulo et al. (2019) validated a Parkour specific repeated sprint ability test (SPRSA) and, whilst it has the advantage of providing an objective and quantifiable measure, it nevertheless only assesses linear performance (when movements are performed in a straight line). As identified by Strafford et al. (2020), Parkour is a highly variable performance landscape, rich in many diverse affordances. With the growing popularity of Parkour and its expansion as a competitive sport, one notable development has been the Parkour speed run event in which Traceurs are required to transition between a pre-determined start and end point in the quickest time possible (Padulo et al., 2019). Speed runs, therefore, provide an alternative means of assessing Parkour performance as they are a recognised form of Parkour competition which captures the variable movements identified by Strafford et al. (2020) and provides an objective and quantifiable measure of performance.

The intrinsic link between functional movement skills, coordinative abilities and conditions of movement in the Athletic Skills Model suggest that performances in standardised athletic tests (e.g., maximal horizontal and vertical jumps) may be related to Parkour speed-run performance. This is because, through previous interactions, Parkour Traceurs will potentially integrate isolated movement components into patterns of coordinated action to support dynamic interactions with obstacles in the Parkour speed route (Strafford et al., 2018; Rudd et al., 2020). As Parkour interventions, including speed-runs, could be implemented to improve functional movement skills in a variety of domains (indoors, outdoors, collectively as members of Parkour team or individually), it is important explore the composition of a battery of standardised athletic tests for functional movement skills which correlate to Parkour performance (Strafford et al., 2020). It is necessary to first understand the physical profile of Parkour Traceurs, and then move beyond description to contextualise functional skills relative to performance in Parkour speed-run settings. Therefore, the aim of this study was to examine which functional movement skills are associated with a fast Parkour speed run time.

Materials and Methods

Participants

Following ethical approval from the lead author's academic institution, nineteen experienced male Parkour Traceurs (age: 23.58 ± 3.01 years, body mass: 73.08 ± 6.60kg, experience: 9.45 ± 3.8 years; stature: 176.45 ± 6.11cm) voluntarily took part in this study. The Parkour Traceurs spent on average 8.08 ± 5.59 hours practising Parkour per week, with 29 ± 19 % of this training time dedicated to physical conditioning. Parkour Traceurs partook in 1 ± 2 Parkour competitions per year. The study procedures were explained in detail to the Parkour Traceurs who subsequently provided written informed consent.

Procedures

Data were collected in three stages at a specialist indoor Parkour training facility in the United Kingdom. The first stage consisted of participant anthropometric measurements and completion of a Parkour questionnaire. The questionnaire was distributed to participants on arrival at the Parkour training facility and comprised of a series of multiple choice and shortanswer questions covering demographic information, Parkour experience, training characteristics, other sporting experiences and their background before practicing Parkour. The second stage consisted of a maximal grip strength measurement and maximal jump tests across eight jump modalities. The third stage consisted of an agility T-test and performing competitive speed runs around an indoor Parkour speed run course. All procedures took place over the course of one day.

Before experimental procedures began, Parkour Traceurs' stature and body mass was measured using a portable stadiometer (Seca Leicester Height Measure, Seca Limited, Birmingham, United Kingdom) and digital scales (HD, Tanita, Tokyo, Japan). Parkour Traceurs' upper and lower body dexterity were also recorded (i.e., hand: what hand do you write with? Foot: If you were to kick a ball at a target, what foot would you kick a ball with?). Parkour Traceurs were right hand dominant (right hand dominance = 100%), and mostly right foot dominant (right foot dominance = 90%, left foot dominance = 10%).

Hand Grip Dynamometry

A digital Hand Grip Dynamometer (Takei Digital 5401, Takei Scientific Instruments Limited, Niigata City, Japan) was selected to record maximal grip strength (kg), as TTK dynamometers have demonstrated higher criterion-related validity and reliability for measuring maximal grip strength than alternative devices (i.e., Jamar and DynEx Dynamometer) (Espana-Romero et al., 2010). Parkour Traceurs could adjust the grip span to a size comfortable to them (range 3.5-7cm). Parkour Traceurs were instructed to look forward, with their feet shoulder width apart whist squeezing the dynamometer gradually and continuously for at least 2 seconds until they reached maximal effort. The lead researcher ensured participants did not touch the dynamometer with any part of their body except the hand being measured. This test was administered 3 times using each hand (left and right alternatively) with 1-minute rest between each trial. For each trial, Parkour Traceurs' elbow position was in full extension (Espana-Romero et al., 2010). The dynamometer display faced the principal researcher, providing blind measurement and reducing learning effects. The highest score for each hand was used for analysis.

Jump Battery

The jump testing battery and procedures for each jump modality are outlined in Table 1. Before completing the jump battery, Parkour Traceurs performed a 10-minute self-selected warm-up, and were instructed not to perform activities which encompassed static stretching (Grosprêtre, Ufland & Jecker, 2018). Following this, Parkour Traceurs completed 5 submaximal jumps for each jump modality. Before each jump modality, the lead researcher performed a demonstration and answered any questions that participants had. Parkour Traceurs then performed maximal jump tests for each jump modality, with at least 2 minutes rest between each of the jump modalities. Parkour Traceurs completed 2-5 jumps of each modality type until the variation between the highest and second highest jumps did not exceed 5% (Grosprêtre & Lepers, 2015). The highest or longest jump value was then used for analysis.

****Table 1.** Jump Battery and Procedures for each Jump Modality (Grosprêtre & Lepers, 2015). (about here)**

Vertical jump height for the squat, counter movement and drop jump modalities was measured through an OptoJump™ photoelectric cell unit connected to a laptop with the proprietary software (Version 1.10.70). The OptoJump™ photoelectric cells (Microgate, Bolzano, Italy) consisted of two parallel bars which were placed approximately 1m apart (one transmitter consisting of 32 light emitting diodes and one receiver, each measuring 100 x 4 x 3cm). The OptoJump™ has reported near perfect reliability and been shown to be strongly correlated with force platforms for the assessment of jump height (Glatthorn et al., 2012). Consistent with Glatthorn et al. (2012), a test-retest protocol undertaken during the pilot stages of the current study also confirmed excellent within- and between-day reliability for the OptoJump^{TM} at determining maximal jump height (Please see supplementary material). A 2-dimensional video camera (Panasonic, HC-V7770EB-K, Panasonic UK & Ireland) recorded vertical jumps in a 4-meter-wide calibrated field of view. The camera was located 4 m perpendicular to the plane of motion and affixed to a rigid tripod with an approximate height of 1.20 m from the ground to lens centre. A 3-5-4 triangle aligned the optical axis 90° to the horizonal plane of motion, minimising parallax and perspective errors. The video and raw data corresponding to each jump was cross-examined to reaffirm consistency in jump technique across the Traceurs**.**

Agility T-test

Based on stop-and-go planned agility, the agility T-test is a valid and reliable measurement of the ability to rapidly change direction with multidirectional displacements (forward sprinting, left and right side shuffling, and backwards running) (Paulo et al., 2000; Sheppard & Young, 2006). The agility T-test was used as the start and end point of the Parkour speed-event is typically linear in fashion, with the route changing in direction and structure thereafter (Padulo et al., 2019). The agility T-test was performed on a wooden floor. Four 30 cm cones which formed a T-shape were situated as markers for turning points. Parkour Traceurs began the test with both feet behind the start line (Cone A) began the test by maximally sprinting 9.14 m forwards, touching the second cone (Cone B) with their right hand, shuffling 4.57m to the left touching the cone (Cone C) with their left hand, shuffling right 9.14 m touching the cone (Cone D) with their right hand, shuffling left 4.57 m back touching the cone (Cone B) with their left hand, and finally backpedalling 9.14 m at speed to the starting point (Cone A). Brower timing gates (Brower Timing Gates, Utah, USA), set at a height of 1 m, measured time to completion and the height of the transmitter was set at 1 m to match the

Traceurs' hip height (Altmann et al., 2015). Timing began on a sound signal and stopped when the Parkour Traceur passed through the timing gate on their return. Parkour Traceurs performed 3 agility T-test trials with 45 s of passive rest between trials. The fastest trial was taken forward for analysis. Parkour Traceurs then rested passively before commencing the next stage of the experimental procedure.

Parkour Speed-Runs

In speed-run competitions, the basic route is set and Parkour Traceurs need to transition from a set start point to an endpoint in the quickest way possible. The route for the speed-run was designed in line with the recommendations outlined in Strafford et al. (2020) and was set by two expert Parkour Traceurs who were unaware of the study aims (Figure 1).

****Figure 1.** Parkour speed route setup. a) top down view, b) front camera view, c) back camera view (dotted line = direction of movement) (about here)**

Before each speed-run, Parkour Traceurs received no instruction on technique, but were instructed to complete the route as quickly as possible. Time to completion was recorded using timing gates positioned at the start and end point of the course. The start and end points were consistent between trials. Parkour Traceurs completed three speed-runs, with self-selected recovery allowed between each attempt, and the fastest trial was used for analysis. Parkour Traceurs were not informed of their run times or the times of other participants until all runs were completed. Video footage of the Parkour speed-runs were recorded using two, 2-dimensional video cameras (Panasonic, HC-V7770EB-K, Panasonic UK & Ireland), which were affixed to rigid tripods and operated in the superior plane, one camera was placed behind the start line and one placed behind the finish line at a height of 7 m from ground to lens centre, which ensured that the full volume of the route was captured.

Data Analysis

Data are reported as mean ± standard deviations, unless otherwise stated. Normality was confirmed though a Shaprio-Wilk test and a parametric method of analysis was employed. Pearson's correlation coefficients (*r)* were employed to examine relationships between athletic skills and Parkour speed-run performance. The reference criteria from Hopkins (2000) were employed to guide interpretation of Pearson's correlation coefficients (0-0.09, trivial; 0.1-0.29, small; 0.3-0.49, moderate, 0.5-0.69, large; 0.7-0.89 very large; 0.9-0.99, nearly perfect; 1, perfect). The alpha level was set at $p < 0.05$.

Results

Functional movement skills

The functional movement skills of the Parkour Traceurs are outlined in Table 2.

Table 2. Performance across the testing battery (Mean ± SD) (insert about here)

Relationship between functional movement skills and Parkour Speed-Run Time

Pearson correlation coefficients between performance variables and Parkour speed-run time are displayed in Table 3.

****Table 3.** Relationships between performance variables and Parkour speed-run time (insert about here)**

Relationship between T-test and Parkour Speed-Run Time

A very large positive correlation was identified between T-test time and time to completion (increase in T-test time = increase in time to completion) (r (19) =.824, p = 0.001).

Relationship between SLJ and Parkour Speed-Run Time

A moderate negative correlation was identified between SLJ height and time to completion (increase in SLJ distance = decrease in time to completion) (r (19) = —.649, p = 0.003)

Relationship between vertical jumps without arm swing and Parkour Speed-Run Time

There was a moderate negative correlation between CMJ and time to completion (increase in CMJ height = decrease in time to completion) (r (19) = —.514, p = 0.024). A moderate negative correlation was identified between CMJ dominant-foot and time to completion (increase in CMJ dominant-foot height = decrease in time to completion) (r (19)= —.550, p = 0.015). A moderate negative correlation was identified between CMJ non-dominant-foot and time to completion (increase in CMJ non-dominant-foot height = decrease in time to completion) (r (19)= —.585, p = 0.009).

Relationship between vertical jumps with arm swing and Parkour Speed-Run Time

There was a large negative correlation between CMJ+ and time to completion (increase in CMJ+ height = decrease in time to completion) (r (19) = —.719, p = 0.001). A large negative correlation was identified between CMJ+ dominant-foot and time to completion (increase in CMJ+ dominant-foot height = decrease in time to completion) (r (19) = —.744, p = 0.001). A large negative correlation was identified between CMJ+ non-dominant-foot and time to completion (increase in CMJ+ non-dominant-foot height = decrease in time to completion) (r (19) = —.769, p = 0.001).

Discussion

Our aim in this study was to investigate which, if any, functional movement skills were associated with Parkour speed-run performance. To achieve this aim, we examined the intrinsic link between functional movement skills, coordinative abilities and conditions of movement outlined in the Athletic Skills Model which suggests that performances in standardised athletic tests (e.g., Agility T-test maximal horizontal and vertical jumps) may be related to performance in their chosen sport or activity, in this case Parkour speed-runs. Using ecological dynamics theory, researchers have provided theoretical proposals and evidence in the form of qualitative, experiential knowledge for how Parkour may develop functional movement skills across domains (Strafford et al., 2018; Strafford et al., 2020). The data presented in this paper, however, supplements these theoretical proposals and existing qualitative experiential knowledge, with empirical evidence that correlates performance on standardised athletic tests of functional movement with Parkour speed-run performance. The findings of the current study can be used to identify which functional movement skills may be developed through engagement with, and exploration of, Parkour landscapes. The correlation analyses revealed that maximal grip strength, squat jump, and drop jump performances were not related to Parkour speed-run time. However, agility T-test performance, standing long jump and counter movement jump (with and without arm swing) were, with quicker speed-run times associated with enhanced levels of these functional movement skills, supporting the notion that functional movement skills (effectivities) provide a strong foundation for performance, as outlined in the Athletic Skills Model (Wormhoudt et al., 2018; Strafford et al., 2018).

The very large positive correlation value between time to completion in the agility T-test and Parkour speed-run suggests that Parkour Traceurs require a similar combination of functional movement skills (running, arm swinging), coordinative abilities (aiming, kinetic differentiating and spatial orientation: in terms linear sprint movement at the start of the speed-run), and basic motor properties (speed), which are assessed in the agility T-test. In both activities, performers must rapidly change direction and speed, based on stop-and-go planned agility with multidirectional displacements of the body in relative space (e.g., forward sprinting, left and right-side shuffling, and backwards run). The Athletic Skills Model proposes the benefits of experience in "donor sports" which can "donate" elements of functional movement skills that enable performers to excel in a target sport through transfer of skill learning between sports or sport elements (Savelsbergh & Wormhoudt, 2019). Strafford et al. (2018) proposed Parkour as a suitable "donor sport" for developing functional movement skills in team sport players. In the context of identifying Parkour as a donor sport, agile athletes can react to perturbations in a performance environment by finding different movement solutions to achieve intended task goals, an essential skill of Parkour and team sports. Findings from the current study imply how exposure to Parkour environments and activities would enrich the repertoire of team sport athletes. The data suggest that experience in Parkour would enable team sports athletes to enrich their functional movement skills required during phase transitions in game play where they require agility to couple their movements at various speeds relative to the movement dynamics of opponents, teammates and direction of the ball (Travassos, Araújo, & Davids 2018; Strafford et al., 2020).

When considering how jump performance was related to Parkour speed-run performance, a determining factor was whether the jump required countermovement. During the speed-run, Parkour Traceurs are required to rapidly (re) organise their body, so a reciprocity between positive and negative muscular work is essential for Parkour performance, which is evident in the moderate negative correlations identified between CMJ, CMJ dominant foot, CMJ non-dominant foot and speed-run time to completion (those with higher jump heights completed the course quicker). Engaging in Parkour may lead to enhanced reciprocity between positive and negative muscular work in basic movement skills, although this warrants further empirical investigation using inverse dynamics.

Another important finding concerned differences in how jumps requiring arm swing, and those that did not, correlated with Parkour speed-run performance. Jumps with arm swing were more strongly correlated with Parkour speed run time than those that did not use arm swing, suggesting that jumps using the arms are more representative and better capture the demands of Parkour. This notable relationship between arm participation and speed-run performance demonstrates how through exposure to a Parkour speed-run environment, perception and action couplings are refined by developing a Traceur's effectivities, in this case residing as the functional movement skill: jumping with arm swing. As a potential donor sport, exposure to Parkour environment may refine an athlete's arm swing in jumping to intercept an object which could be beneficial for performance in team sports. An effective use of arm swing may also lead to enhanced awareness of body orientation leading to the regulation of balance and postural control following physical challenges with opponents jumping to intercept the same object (Puddle & Maulder 2013; Maldonado, Soueres, & Waiter 2018).

From an ecological dynamics perspective, the open and exploratory nature of the Parkour landscape means that it offers opportunities for novel interactions (affordances) founded on basic athletic skills for jumping, landing, twisting, turning and changing direction. These opportunities for novel interactions, with different obstacles, ledges and surfaces may not have an immediate or obvious solution, and require Parkour Traceurs to adapt and be creative in the way they interact with them to solve performance problems efficiently (i.e., complete the route in the quickest time possible). Therefore, Parkour Traceurs who are repeatedly exposed to such environments have opportunities to explore and discover solutions to navigate a speed run route and so develop these functional movement skills. Data from the present study suggest that performance in Parkour-speed-runs are underpinned by functional movement skills (jumping, running; arm swinging) and condition of movement (agility), all of which encapsulate elements of basic motor properties (speed; strength). These findings suggest how Parkour could serve as an effective donor sport for training and skill development of team sport athletes. Future research may wish to investigate if Parkour interventions are effective in developing other functional movement skills and specific motor properties. Based on findings reported here, we would recommend that testing batteries employed to evaluate the effectiveness of such interventions are inclusive of the following components: agility T-test, CMJ jumps without arm swing using both feet and the dominant and the non-dominant foot, standing long jump, and CMJ jumps with an arm swing component using both feet and the dominant and the non-dominant foot.

Whilst the current study has presented data that correlates parkour performance with certain measures of functional movement skills, it is not possible to definitively conclude the nature of this relationship (i.e., if one is responsible for the change in the other). Therefore, intervention studies which expose participants to either functional movement tests or Parkour training, before examining the effects of Parkour training on performance would be valuable avenues for researchers to consider in the future. Researchers could also extend from this study by collecting physiological variables to examine the metabolic contribution of Parkour speed-runs.

Conclusion

This study has examined which functional movement skills correlated with Parkour speed-run performance. The correlation analysis revealed that agility T-test performance, standing long jump and counter movement jump (with and without arm swing) performances were related to Parkour speed-run performance. In line with the intrinsically-linked building blocks in the Athletic Skills Model, the data from the present study suggest that performance in Parkour-speed-runs are underpinned by functional movement skills (jumping, running; arm swinging) and condition of movement (agility), all of which encapsulate elements of basic motor properties (speed; strength). These findings provide support for the notion that functional movement skills (effectivities) are not isolated movements, but skills that can be integrated to support functional interactions of athletes within a Parkour speed-run performance environment. Data suggest Parkour Traceurs who are repeatedly exposed to Parkour speed-run environments develop specific functional movement skills and as such have the opportunity to explore and discover solutions to navigate speed run environments more efficiently. From a practical perspective, the agility T-test, SLJ, and CMJ with and without arm swing should form the base of testing batteries that evaluate the physical effects of Parkour speed-run interventions on functional movement skills.

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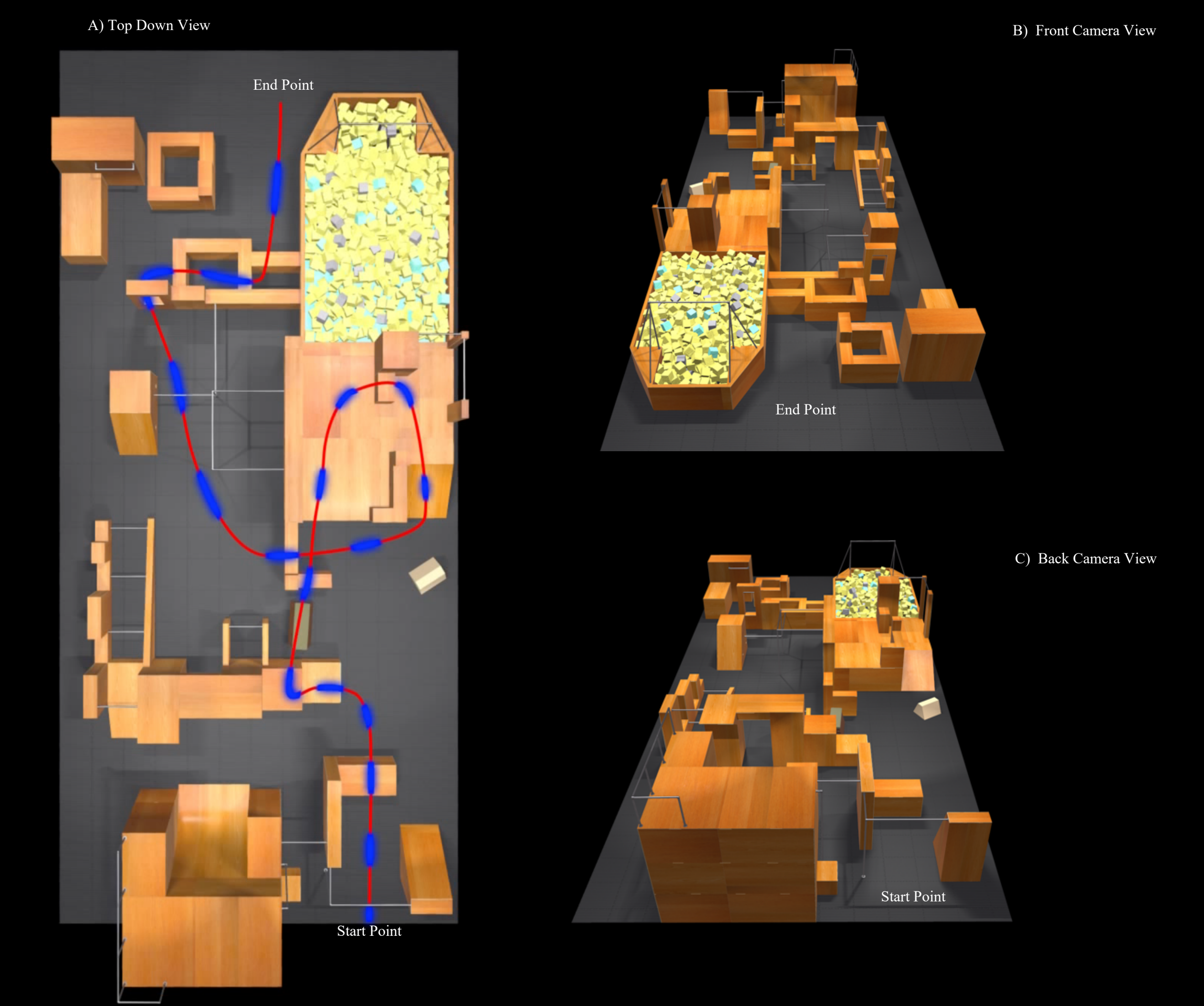
A) Top Down View
End Point
Start Point
B) Front Camera View
End Point
C) Back Camera View
Start Point