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Comparative User Experience of VR Locomotion: Cyberith Virtualizer ELITE 2, Virtuix Omni Pro, and Free Walking

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ABSTRACT

Virtual reality (VR) locomotion platforms enhance immersion but introduce varied user experiences. This study comparatively evaluated the Cyberith Virtualizer ELITE 2, Virtuix Omni Pro, and controller-based Free Walking to assess their physical and emotional demands, operability, safety, and user preference. A user study with 31 participants involved performing standardized tasks across all three methods, utilizing questionnaires (including SSQ) and performance metrics. Free Walking emerged as the most preferred method, offering superior control and the fastest task completion, and was perceived as the least physically and emotionally demanding. However, omnidirectional treadmills presented notable trade-offs. The Virtuix Omni Pro, despite being perceived as the most physically and emotionally demanding, surprisingly induced the lowest levels of cybersickness (SSQ scores) and resulted in the fewest task errors. In contrast, the Cyberith Virtualizer ELITE 2, while offering a more natural walking feel and better perceived operability than the Omni, led to the highest cybersickness levels and slower task completion. These findings reveal a critical divergence between subjective user perception and objective physiological impact in VR locomotion, highlighting a complex interplay between perceived effort and physiological response.

Keywords: VR locomotion, Omnidirectional treadmill, User experience, Cybersickness, Human-Computer interaction, Cyberith virtualizer ELITE 2, Virtuix Omni Pro, Free walking

INTRODUCTION

Problem Statement

Virtual reality research involving locomotion platforms has expanded significantly over the last decade (Hager et al. (2019)). Beyond visual immersion via head-mounted displays (HMDs), these devices track movement and impose unique physical and emotional demands, raising questions about their usability and accessibility for average users.

Existing literature has evaluated platforms like the Cyberith Virtualizer ELITE 2 (Diaz et al. (2024)) and the Virtuix Omni Pro (Bashir et al. (2023)), noting that while they enable infinite walking space, they involve distinct trade-offs. Conversely, free walking typically necessitates techniques like teleportation or redirected walking (Martinez et al. (2022)), which have inherent limitations.

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Despite these findings, no study has directly compared the Virtualizer ELITE 2 and Virtuix Omni Pro. This paper addresses that gap by evaluating both devices alongside a free-walking baseline using Meta Quest 3 controllers.

RELATED WORK

Cyberith Virtualizer ELITE 2

Recent work by Diaz et al. (2024) compared four omnidirectional systems (Walk & Teleport, EKTO VR Voyager Boots, Cyberith Virtualizer ELITE 2, and Infinadeck). While participants favored the EKTO boots for hand-interaction tasks, the study only identified a "best" device rather than a comprehensive ranking—a limitation our research addresses.

Evaluating the Virtualizer ELITE 2 against natural walking, Chakraborty et al. (2024) found that participants consistently overshot distances and performed worse in path integration tasks when using the platform. Similarly, Homami et al. (2025) compared the Virtualizer 2, KAT VR Mini, and natural walking in maze navigation. Natural walking remained the most efficient and preferred method. Although the Virtualizer was better received than the KAT VR Mini—which users found physically taxing—it remained less effective than natural movement.

Virtuix Omni Pro

Bashir et al. (2023) compared the Virtuix Omni Pro to a unidirectional treadmill, finding that both increased cybersickness within ten minutes. However, the Omni Pro induced significantly higher sickness, greater postural instability, and unnatural gait, leading to poorer task performance. In a wayfinding study with visually impaired participants, Han et al. (2022) compared the Omni Pro to HTC Vive Trackers (body-mounted step tracking). Results showed that the treadmill improved route recall, while the trackers led to more accurate obstacle memory.

Earlier work by Hooks et al. (2020) compared the bowl-based Omni Pro to the flat-based original Cyberith Virtualizer, finding comparable performance but a user preference for the Omni Pro. These findings underscore the need to evaluate the updated Virtualizer ELITE 2 against current standards.

Free Walking

Free walking is the most natural VR locomotion technique, reducing cybersickness through realistic movement; however, it is strictly limited by physical space. When spatial constraints necessitate controller-based navigation, cybersickness typically increases. While redirected walking (Marraffino et al. (2024)) attempts to expand the usable area, it can also induce significant discomfort.

Research by Malhotra (2024) indicates that integrating physical movement—rather than relying solely on manual controller inputs—mitigates cybersickness. Consequently, locomotion platforms offer a dual solution: they

bypass physical space limitations while maintaining the physiological benefits of active movement, potentially enabling a more seamless VR experience.

METHODOLOGY

Locomotion Stations

Cyberith Virtualizer ELITE 2

A second-generation omnidirectional treadmill featuring a flat, slightly elevated platform that dynamically adjusts its slope to stay oriented with the user. Movement is facilitated by specialized overshoes that enable controlled sliding (Hager et al. (2019)).

Virtuix Omni Pro

A static, bowl-based omnidirectional treadmill (Avila and Bailey (2014)). Unlike the Virtualizer's dynamic adjustment, its concave base provides a constant incline in all directions. Movement is captured via two tracking pads integrated into proprietary Omni shoes.

Free Walking

A hybrid locomotion technique combining Full Gait and Non-Spatial Steering (Martinez et al. (2022)). Users navigate via Meta Quest 3 joysticks (left for translation, right for rotation) while retaining the ability to move physically within the tracking boundary.

Experiment

We employed a within-subjects design using a Latin square to counterbalance the six possible device orders across three Unity levels. Participants completed questionnaires before and after using each device to assess physical and emotional impacts, with additional baseline and concluding surveys at the start and end of the session.

All trials occurred in a controlled environment. To ensure comparability, movement speed on the locomotion platforms was capped to match the controller-based movement speed.

Tasks

The Unity environment consists of the following scenes:

Training. Participants complete a familiarization scene to practice device locomotion and basic VR interactions (e.g., grabbing, climbing), establishing a baseline for all experience levels.

Plank Walk. Participants climb a ship's mast and cross a narrow, highly elevated plank to measure emotional exhaustion.

Labyrinth. Inspired by Homami et al. (2025), users navigate a dark, procedurally generated maze. A held torch aids visibility and discourages reliance on the treadmill's support ring.

Squid Game. Inspired by the series (Hwang (2021)), this scene features three tasks: can-throwing (evaluating interaction while on treadmills), sprinting (testing stamina), and navigating a memorized path across platforms (where missteps trigger a respawn).

Data Collection & Metrics

To evaluate performance and user preference, we collected the following metrics:

Simulator Sickness Questionnaire (SSQ). Administered as a baseline and after each condition, the SSQ (Kennedy et al. (1993)) measures 16 symptoms across three factors: nausea, oculomotor, and disorientation. This tool is a standard reliability measure in similar locomotion studies (e.g., Diaz et al. (2024)).

Initial Questionnaire. Collected demographics (age, gender, height, weight), VR/treadmill experience, and physical fitness. We also noted time since the last meal to account for potential influence on fatigue or nausea.

User Experience (UX). Adapted from Bashir et al. (2023), participants rated movement difficulty, enjoyment, fatigue, safety, and future intent on 5-point scales. Qualitative feedback and a final ranking of devices (e.g., "most physically demanding") were collected after all trials.

Task Performance. Automated in-game logging recorded completion times and error counts (e.g., falls during the "Plank Walk" or throws required in the "Squid Game" task).

Behavioral Observations. Video recordings captured physical behavior, such as the frequency of grasping treadmill support rings for stability.

RESULTS

Participants

A total of 31 participants (29 male, 2 female) took part, with an average age of 26.1 years (range: 19–41). The cohort averaged 81 kg (range: 58–120 kg) in weight and 1.81 m (range: 1.62–2.05 m) in height. Thirty participants completed the study; one withdrew due to nausea after testing only the Virtualizer and Free Walking. Of the group, 53% had previously participated in a research study, and 35% had participated in VR-specific studies. The cohort was relatively balanced regarding VR headset expertise, with most reporting 10 to 100 hours of prior use. Conversely, 26 participants had never used a locomotion platform, and the remaining five reported fewer than 10 hours of experience. Self-reported physical fitness skewed high on a five-point scale (1: very unfit, 5: very fit). No participants selected 1, while 44% rated themselves at 4, 38.5% at 3, 13.8% at 5, and 3.7% at 2. These figures represent subjective self-assessments. Regarding meal timing, 41.9% had eaten more than three hours prior to the study. The remainder had eaten within three hours (16.1%), two hours (16.1%), one hour (22.6%), or 30 minutes (3.2%) of their session, which may influence exhaustion levels during treadmill use.

SSQ

Table 1 presents SSQ scores across nausea, oculomotor strain, and disorientation. To isolate the immediate impact of each locomotion method and avoid carry-over effects, we analyzed only the first condition encountered by participants (Virtualizer: n = 11; Omni: n = 10; Free Walking: n = 10) against the baseline (n = 31). Higher scores represent increased symptom severity (Kennedy et al. (1993)).

Table 1: SSQ scores (before and after every first device).

	Nausea	Oculomotor	Disorientation	Average Total SSQ	Median Total SSQ
Before the study	13.54	16.87	17.06	18.22	7.48
After Virtualizer	70.25	40.66	74.66	67.66	52.36
After Omni	23.85	9.10	19.49	19.07	9.35
After FreeWalk	44.84	24.26	44.54	41.51	26.18

Due to the non-normal distribution of Omni and Free Walking scores, medians provide the most reliable insight. Nevertheless, a one-way ANOVA revealed significant differences between groups ($F(2, 28) = 3.54$, $p = 0.0436$).

Which is the Best Device?

The comparative rankings across the three locomotion devices revealed a clear hierarchy of preference among the 30 participants who completed the final evaluation. Free Walking was the most preferred method, with 56.7% of the cohort ranking it as the best overall experience. The Virtualizer followed as a middle-tier option, most frequently ranked in second place (43.3%). Conversely, the Omni was the least preferred, with a majority of 56.7% ranking it third. One participant's data was excluded from this analysis as they did not submit the final form.

Task Performance

First-run completion times differed significantly across devices. Free Walking was fastest (415,084 ms; 6m 55s), followed by the Omni (536,702 ms; 8m 57s), and the Virtualizer (634,865 ms; 10m 35s). As noted earlier, capped speeds provide Free Walking an inherent time advantage, as controller inputs sustain maximum speed continuously, unlike intermittent foot-based platform tracking.

First-run error rates (combined falls in 'Squid Game' and 'Plank Walk', plus required throws in 'Squid Game Cans') showed the Omni was the most accurate interface (12.40 mean errors). Free Walking yielded a moderate error rate (14.80), while the Virtualizer produced the most mistakes (19.54). Across all devices, the total average completion time was 398,658 ms (6m 39s). The Labyrinth required the most time (180,890 ms), followed by Squid Game (156,289 ms), Plank Walk (84,003 ms), and Training (67,158 ms). Task-specific errors averaged 0.8 falls for the Plank Walk, and 1.8 falls alongside 12.6 throw attempts for the Squid Game.

Physical Demand of the Devices

Participants categorized the devices physical exertion as most relaxed, medium, or most exhausting, with overlapping classifications permitted (e.g., rating both treadmills as most exhausting). Free Walking was overwhelmingly identified as the most relaxed method (28 relaxed, 2 medium/exhausting). The Omni Pro was perceived as the most exhausting (0 relaxed, 4 medium, 26 exhausting). The Virtualizer ELITE 2 was primarily viewed as medium demand (1 relaxed, 23 medium, 6 exhausting).

Emotional Demand of the Devices

Participants rated the devices' emotional demand (subjective mental effort or frustration) as most relaxed, medium, or most exhausting, with overlapping classifications permitted. Free Walking was rated the least emotionally demanding (18 relaxed, 8 medium, 4 exhausting). Conversely, the Omni was perceived as the most exhausting (5 relaxed, 12 medium, 13 exhausting). The Virtualizer received mixed evaluations (12 relaxed, 9 medium, 9 exhausting).

Usability, Stability, and Safety

Participants evaluated usability and safety across four metrics using 5- point scales, where higher scores consistently indicated a better experience (e.g., 1 = very difficult/unstable/afraid, 5 = very easy/stable/not afraid at all). Regarding basic locomotion, Free Walking was perceived as the most intuitive. It achieved the highest mean ratings for walking in a straight line (4.48) and changing direction (4.23), with no participant rating it as "very difficult" (1). Between the two treadmills, the newer Virtualizer ELITE 2 was evaluated more favorably than the older Virtuix Omni Pro for both walking straight (3.16 vs. 2.93) and changing direction (3.68 vs. 2.60). Notably, no participant rated turning on the Omni as "very easy" (5).

In terms of physical confidence and perceived stability, Free Walking again scored highest (4.00), though the Omni (3.73) slightly edged out the Virtualizer (3.58). For fear of falling or slipping, the Omni and Free Walking suggested equivalent levels of perceived safety (averaging 4.23), while the Virtualizer scored slightly lower (4.00). Despite this, extreme feelings of insecurity were rare across the hardware: no participant rated the Omni as "very unstable" (1), nor did anyone assign the Virtualizer the highest level of fear (1).

Qualitative User Feedback Summary

Open feedback revealed distinct perceptual profiles for each locomotion method. The Cyberith Virtualizer ELITE 2 was praised for realistic rotational movements but criticized for a "slippery", low-friction surface that required strenuous effort to maintain balance. The Virtuix Omni Pro was consistently described as physically demanding and unintuitive; users cited difficulties with precise directional changes and an unnatural walking gait caused by its bowl-shaped platform. Finally, Free Walking was lauded for simple controls and a high freedom of movement, though users noted a reduced sense of immersion compared to the treadmills and occasional joystick-induced motion sickness.

Hip Attachment

19 participants used the hip attachment on both the Virtualizer and the Omni, while seven did not use it on either device. Video recordings were unavailable for four additional participants, and one participant could not use both devices due to nausea. Notably, no participant used the attachment on only one device; they either used it on both or not at all.

Participants were also asked whether the hip attachment improved their sense of security on a 5-point scale, with 5 indicating maximal improvement. Overall, 33.9% rated it as 5, 50.8% as 4, 10.2% as 3, and 5.1% as 2. No participant rated it as 1 (not helpful at all).

DISCUSSION

As qualitative results indicate, participants found the Virtuix Omni Pro arduous and clumsy, the Cyberith Virtualizer more natural but strenuous, and Free Walking superior for control despite other drawbacks.

However, these perceptions contrast with objective data, creating a compelling paradox: the system perceived as "worst" objectively performed best in critical areas. This disconnect suggests user preference does not always align with physiological comfort or optimal performance.

Contrasting Subjective Impressions and Objective Performance

Participants rated Free Walking as the least demanding, yet SSQ data showed the Omni Pro induced the lowest cybersickness, contradicting its perception as the most exhausting system. This discrepancy contradicts earlier findings (Bashir et al. (2023)), potentially because the Omni's unnatural overshoes and noise increased perceived effort despite lower symptoms. Alternatively, consistent with Malhotra (2024), the treadmill's high physical engagement may reduce visual-vestibular conflict, whereas joystick-based Free Walking lacks the body movement necessary for such mitigation. Conversely, the Virtualizer was judged more natural than the Omni but yielded the highest cybersickness scores. This suggests its low-friction surface and balance demands impose unique vestibular strains. Ultimately, the Omni's status as the least preferred system confirms that user preference can diverge significantly from optimal task performance.

Task Performance and Usability

Completion times and error rates reinforce the trade-off between intuitiveness and control. Free Walking was fastest overall, confirming its efficiency for structured VR tasks (Homami et al. (2025)).

Physical and Emotional Demand

Both treadmills were significantly more demanding than Free Walking, with the Omni perceived as most exhausting, supporting evidence that omnidirectional treadmills impose substantial physical burdens (Bashir et al. (2023); Homami et al. (2025)).

Hip attachments improved security for most participants, mitigating the fear of falling. This suggests future designs should prioritize supportive harnesses to balance safety and comfort, though the need for support appears to be a user-specific rather than device-specific trait.

Implications for VR Design and Use

The contrast between preference and performance has major implications. While joystick-based Free Walking remains the most accessible consumer solution, it carries higher cybersickness risks. For enterprise or training scenarios where precision and reduced sickness are critical, the Omni may be superior despite lower satisfaction.

The Virtualizer presents a mixed profile: its perceived naturalness holds promise for entertainment, but current design limitations regarding cybersickness must be addressed through further refinement.

Comparing Old and New Virtualizer

While previous comparisons favored the Omni over the original Virtualizer (Hooks et al. (2020)), our results show the Virtualizer 2 is now more popular despite higher cybersickness. Future research should compare the Virtualizer 2 with the newer Virtuix Omni One.

Unexpected Findings

The study's most counterintuitive result was the inverse relationship between the Omni's perceived experience and objective SSQ scores in Table 1. Despite being the least preferred and most demanding device, the Omni Pro produced the lowest cybersickness. We hypothesize this stems from high sensory-motor engagement. The Omni's high-friction surface necessitates deliberate, high-effort movements that generate powerful proprioceptive feedback. This intense physical signal may "ground" the user, reducing the impact of the visual-vestibular conflict that causes cybersickness. This challenges the assumption that "natural" or "effortless" motion is always superior. Designed physical resistance, while subjectively less pleasant, may be essential for creating physiologically comfortable VR experiences.

Limitations and Future Work

Limitations include a demographic imbalance (29 male, 2 female), restricting gender generalizability, and the exclusion of one incomplete dataset. Additionally, varying ambient temperatures may have influenced SSQ symptoms (e.g., sweating) and participant performance, highlighting the need for strictly climate-controlled testing environments. Future research should leverage our within-subject design for a sequential analysis of cybersickness accumulation. Employing linear mixed-effects models to examine SSQ score transitions (e.g., moving from Free Walking to the Omni Pro vs. Virtualizer) could further clarify carryover effects and the Omni Pro's unique mitigating properties. Finally, as no subgroup analysis was performed, future studies

should investigate how device preference is influenced by specific user characteristics: physical fitness, weight (above/below 100kg), prior VR experience, time since last meal, and general motion sickness susceptibility (e.g., reading in a car).

CONCLUSION

This study compared three VR locomotion methods—Cyberith Virtualizer ELITE 2, Virtuix Omni Pro, and controller-based Free Walking—evaluating physical/emotional demand, operability, comfort, safety, and preference to bridge the comparative gap between treadmill systems. Free Walking emerged as the preferred method, leading in ease of use, control, and task speed while being rated the least demanding. Crucially, the results revealed a nuanced relationship between effort and cybersickness. Although the Virtuix Omni Pro was rated the most demanding and difficult to operate (e.g., steering), it produced the lowest SSQ scores and fewest task errors. This contradicts hypotheses of poor overall performance, suggesting that high physical effort may paradoxically mitigate physiological discomfort. Conversely, the Cyberith Virtualizer ELITE 2 offered a more "natural" gait but induced the highest cybersickness and slower completion times. Both treadmills ensured safety when hip attachments were utilized. These findings highlight a disconnect between subjective perception and objective physiological response. While Free Walking remains the baseline for accessibility, the Omni Pro's results suggest that physical engagement—even if strenuous or less intuitive—may reduce visual-vestibular conflict. Limitations include demographic imbalance, uncontrolled environmental temperature, and minor data loss. Future research should utilize diverse cohorts and investigate the physiological mechanisms underlying these results.

Ultimately, these findings challenge the pursuit of "perfect naturalism" in VR. Physical resistance and effort may be essential for physiological comfort, suggesting the most effective system is not the one that feels easiest, but the one that most convincingly engages the body.

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