

Regardless of Age, Locomotor Habituation is Observed with Exposure to Virtually- Induced Fall-Related Anxiety

Kelly Poretti

Baltimore VA Medical Center

Quentin Sanders

George Mason University

Nathalia Peixoto

George Mason University

Toby J. Ellmers

Imperial College London

Christopher K. Rhea

Old Dominion University

Tiphanie E. Raffegeau

`traffege@gmu.edu`

George Mason University

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Regardless of Age, Locomotor Habituation is Observed with Exposure to Virtually-Induced Fall-Related Anxiety

Kelly Poretti, PhD,^{1,2} Quentin Sanders, PhD,³ Nathalia Peixoto, PhD,⁴ Toby J. Ellmers, PhD,⁵ Christopher K. Rhea, PhD,⁶ Tiphane E. Raffegeau, PhD¹

¹School of Kinesiology, George Mason University, Manassas, VA, USA

²VA Maryland Healthcare System, Baltimore, MD, USA

³Department of Mechanical Engineering and Bioengineering, George Mason University, Fairfax, VA, USA

⁴Department of Electrical and Computer Engineering, George Mason University, Fairfax, VA, USA

⁵Department of Brain Sciences, Imperial College London, London UK

⁶Ellmer College of Health Sciences, Old Dominion University, Norfolk, VA, USA

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Corresponding Author

Tiphane E. Raffegeau, PhD
George Mason University
10890 George Mason Circle, Suite 220
Manassas, VA 20110
Email: traffege@gmu.edu

Abstract

Background

Up to 60% of older adults experience fall-related anxiety, which can increase fall risk. Virtual high elevations induce fall-related anxiety that diminishes with time, offering a means for emotional and motor habituation. Age-related gait habituation differences observed in other environments might also appear in virtual anxiety-inducing settings. The purpose of this study is to determine age-related gait habituation differences across time and repeated immersion in virtual anxiety-inducing settings.

Methods

Participants ($N = 30$, 14 older adults) experienced four walking trials: one minute at virtual low elevations (ground), five minutes (I1) at virtual high elevations (~15m), one minute at virtual low elevation, five minutes (I2) at virtual high elevations. Steady state gait parameters from the first (T1) and last (T2) six steady state steps were analyzed.

Results

Both age groups habituated similarly, walking with longer steps over time at low [$F = 10.25$, $p = .001$] and high [$F = 83.78$, $p < .001$] elevations. In I1, both groups walked with longer, ($F = 15.50$, $p < .001$), faster ($F = 7.05$, $p = .013$) steps at T2 versus T1. Both groups walked with longer ($F = 21.17$, $p < .001$), faster ($F = 16.50$, $p < .001$) steps at T1 of I2 versus T1 of I1.

Conclusion

Young and older adults similarly habituated gait and showed savings of habituated motor patterns specific to virtual anxiety-inducing settings. Our results provide evidence supporting the potential use of the VR paradigm as a habituation intervention to reduce fall-related anxiety in older adults.

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59 **Key Words**

60 Falls, fear of falling, gait, virtual reality

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INTRODUCTION

Perceived threats to balance can lead to emotional responses such as concerns and anxiety about falling, and alter behavior that may increase fall risk [1]. Up to 60% of older adults report concerns and/or anxiety about falling [2], which has been shown to independently predict future falls [3]. These emotional responses can disrupt attentional and motor control in young and older adults, as individuals reallocate their attention to rumination when experiencing a postural threat and change their motor behaviors toward more protective mechanisms to prevent falling [1,4–6]. However, with an already limited cognitive motor capacity [7], these disruptions may be even larger in older adults [1]. In fact, older adults with excessive fall-related anxiety reallocate their already limited cognitive resources away from the motor complexity of unpredictable real-world tasks [1,8], disrupting movement planning and required attention for rapid and active reactive stepping patterns [9,10] when experiencing postural threat [11].

Current approaches to reduce fall risk focus on restoration of physical function, although the current World Falls Guidelines [12] reflect a need for multi-component interventions. Virtual reality (VR) has emerged as a safe, cost-effective tool for treating psychological aspects of anxiety disorders [13], suggesting it may be an effective means of implementing multi-component fall prevention interventions. VR has been used to treat and manage anxiety disorders by providing experientially rich environments where individuals can confront and diminish their anxiety through habituation [13]. Specifically, repeated exposure to anxiety-inducing VR environments reduces acrophobia symptoms [13], increases stress-relief for those with generalized anxiety disorder [13], and reduces PTSD symptoms [13,14]. Although concerns about falling have been treated with traditional cognitive behavioral therapy methods [15], little

research has focused on implementing VR-based exposure therapy. Emerging evidence shows reductions in concerns of falling in older adults following a three-week treadmill-based VR intervention where participants viewed changing city scenes (i.e. icy paths, obstacles, etc.) [16]. However, we do not know if or how cautious behaviors are saved (i.e. how learned movement patterns are stored and recalled) between repeated exposures to anxiety-inducing settings.

Simulating high elevation settings in VR has been used to induce a fall-related anxiety response and cautious gait patterns that diminished with time in young [17,18] and older adults [19], offering a potential tool for emotional and motor habituation to fall-related anxiety. It is plausible to predict that due to age-related differences in habituation of stepping patterns in other physical [20,21] and virtual environments [22], age-related differences in habituation to the anxiety-inducing environment might also exist. Typically, locomotor habituation is studied using a split-belt treadmill paradigm, where we see age-related differences in locomotor habituation, indicating that older adults have a reduced gait habituation ability [20]. Like the split-belt paradigm, fall-related anxiety alters perception of environmental stimuli that changes the current task goal and requires gait habituation. Older adults have demonstrated impairments in locomotor habituation [20], potentially related to their cognitive-motor capabilities, which would hinder adaptive walking in the virtual high elevation setting.

The purpose of this study is to (1) extend previous research to determine age-related differences in anxiety-related gait habituation in response to anxiety-inducing VR settings and (2) to examine age-related differences in the savings of gait habituation between repeated immersions. Specifically, we seek to investigate age-related

locomotor habituation through differences in spatiotemporal outcomes (gait speed, step length, step width, and double support percentage) across time and repeated immersions to fall-related anxiety settings. We predicted that we would reveal age-related gait differences in response to the anxiety-inducing virtual environment through faster gait speeds, longer step lengths, and decreased time in double support over time. Additionally, we predicted that older adults would habituate more slowly compared to young adults within an immersion and would have lower levels of locomotor savings between immersions.

METHODS

Participants

All procedures were approved by the George Mason University's Institutional Review Board and informed consent was provided. Participants were excluded if they had any neurological, orthopedic, or cardiovascular conditions, or suffered from excessive motion sickness or vertigo. A total of 18 older adult participants between the ages of 60 and 85, without any neurological impairment, who were able to walk comfortably for 20 minutes unassisted and with breaks, and reported their vision and hearing corrected-to-norma were recruited. A total of 17 able-bodied young adults (age 18-35) were recruited from the university that met the same criteria. Due to self-reported fear of heights, two older and one young adult were unable to complete study procedures. Two additional older adults were unable to complete study procedures due to self-reported dizziness during VR immersion.

Baseline Assessments

Prior to VR immersion, participants completed several surveys assessing anxiety and concerns about falling, as well as a cognitive assessment evaluating inhibitory control and attention. Participants completed the Short Falls Efficacy Scale – International [23] to measure concerns about falling. State and trait anxiety were assessed using the State-Trait Anxiety Inventory [24]. Participants completed the Flanker Inhibitory Control and Attention Test on an iPad administered through the NIH Toolbox [25].

Procedures

Participants were fitted with the HTC Vive (Pro 2, Bellevue, WA) head-mounted system (HMD) displaying a virtual walkway (Unity3D, San Francisco, CA) matched to a real path (40 cm wide by 1.7 cm high). The real path was adjusted to each participant's step length so all participants took roughly the same number of steps per pass on the walkway during walking trials. To adjust the path length, participants completed a baseline walking assessment on a pressure sensitive mat (Protokinetics, Havertown, PA), walking back and forth along the mat for one minute, past each end of the mat to eliminate gait initiation, turning, and gait termination steps from the sample. Average step length from the PKMAS software [26] was used to adjust the length of the walkway to the nearest 6 inches (e.g. the length of one tile) so each participant experienced a minimum of two steady state steps per pass [27]. Participants wore motion trackers (HTC Vive, version 2.0 and 3.0) attached to both feet. A small subset of participants (four young and four older adults) wore a wrist-worn heart rate monitor (Empatica, Cambridge, MA) as part of a preliminary analysis of the habituation of physiological arousal (Supplementary Data). After a two-minute familiarization period, participants

completed four walking trials: one minute at virtual low elevation (ground level), five minutes (I1) at virtual high elevation (~15m above ground), followed by one minute at virtual low and then five minutes (I2) at virtual high elevation (Figure 1). During walking trials, participants walked along the walkway in the virtual environment at their preferred ‘comfortable speed’, turned 180° at the end of the walkway, and continued walking back and forth until instructed to stop.

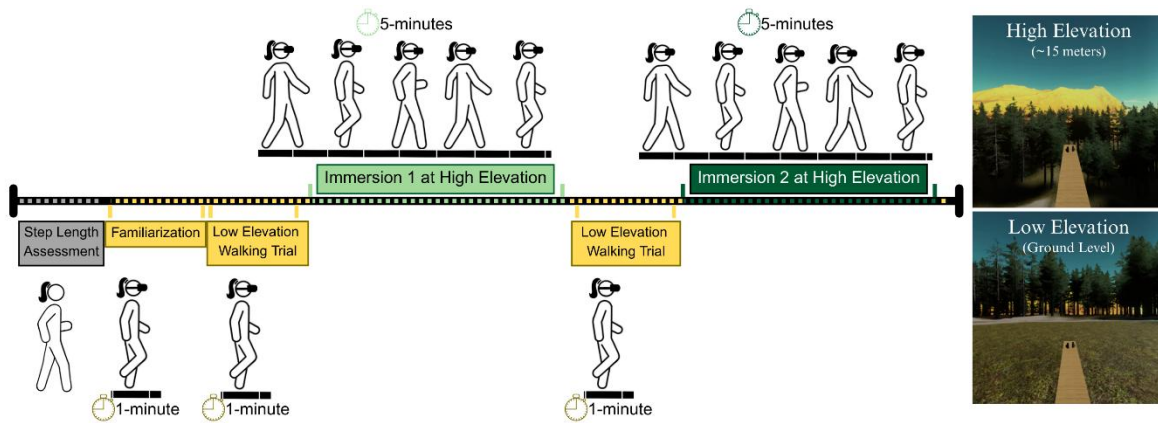


Figure 1: Virtual Environment. Individuals are fitted with a commercially available head-mounted VR system displaying a wooden plank that is matched to the real-world. Participants experience low (ground level, right bottom image) and high (15m above the ground, right top image) virtual elevations while walking.

Data Processing

Foot trackers and HMD collected data at a variable sampling rate that was resampled to a 100Hz frequency [28] using a custom MATLAB script (v2022b, Mathworks, Natick MA). Data was gap-filled and filtered using a low-pass fourth order Butterworth filter. Foot contacts were identified as the peak distance between the HMD and each foot tracker, where local maxima were defined as initial contact and local

minima were defined as foot off [29]. Using a visual interface, we removed turning steps between passes on the walkway. We calculated gait parameters from 3D position data of the foot trackers from the remaining steady state steps following definitions from Winter et al [30]. After removing gait initiation and termination (4 steps or 2 gait cycles), we extracted the first six (or the first 3 gait cycles, T1) and the last six steady state steps (or the last 3 gait cycles, T2) for each walking trial for statistical analysis [31].

Heart rate variability (HRV) was calculated from data of the wrist-worn device that was filtered with a fourth order Butterworth filter. We defined HRV as the inter-beat-interval, calculated as the time difference between peaks from raw photoplethysmography data that was recorded at 64Hz. Average HRV was calculated for T1 and T2 of both VR immersions for the sub analysis (Supplementary Data).

Statistical Analysis

Linear mixed-effect regression (LMER) were conducted in RStudio with lme4 [32] and lmerTest [33] packages. According to LMER guidelines, we calculated the mean of each variable, then subtracted the mean from each data point to obtain mean-centered values so that intercepts represented average performance. The best fitting LMER model was used to assess habituation of step length, step width, gait speed, and double support percentage due to Age (2 levels: young adults (reference), older adults), Elevation (2 levels: Low, (reference), High) and Time (2 levels: T1 (reference), T2) during the first trials at each height. The best fitting LMER model compared step length, step width, gait speed, double support, and HRV percentage due to Age (2 levels: young adults (reference), older adults), Immersion (2 levels: I1 (reference), I2), and Time (2 levels: T1 (reference), T2). Significant three-way interactions were further broken down to explore age-related differences in Immersion or Time. Data were

analyzed to ensure that assumptions were met. Factors were contrast coded so Beta weights represented a one-unit unstandardized change between levels. Effect sizes adjusted for small sample sizes were calculated for the preliminary analysis of HRV using Hedge's *G* and interpreted as 0.2 = small, 0.5 = medium, and 0.8 = large effects (Supplementary Data) [34].

RESULTS

A total of 30 participants (*N* = 30, 14 older adults) were included in this analysis (Table 1).

Table 1: Participant Characteristics

	Older Adults (<i>N</i> = 14)	Range		Young Adults (<i>N</i> = 16)	Range		t-test
	Mean(SD)	Lower Limit	Upper Limit	Mean(SD)	Lower Limit	Upper Limit	<i>p</i> - value
Age (y)	71.7(4.5)	63.9	80.9	22.4(3.8)	18.7	27.5	<.001
Height (cm)	164.6(11.4)	145.1	182.4	166.1(10.4)	151.4	182.3	.732
Mass (kg)	80.9(21.1)	49.9	114.5	71.6(13.6)	47.6	99.1	.168
Leg length (mm)	90.1(6.2)	79.1	97.5	89.0(6.7)	79.2	100.6	.697
STAI-T (score [20-80])	31(7)	23	45	36(8)	26	59	.075
STAI-S (score [20-80])	22(3)	20	30	34(12)	20	45	.001
FES-I (score [7-28])	9(3)	7	18	8(3)	7	19	.490
Flanker Test (score)	1.33(0.25)	1.01	1.78	1.91(0.45)	1.22	3.03	.002

Note: SD = standard deviation; y = year, cm = centimeters; kg = kilograms; mm = millimeters, STAI-S = State-Trait Anxiety Inventory – State, STAI-T = State-Trait Anxiety Inventory – Trait, FES-I = Short Form Falls Efficacy Scale International, Flanker Test = National Institutes of Health Flanker Test of Inhibitory Control, *Significant differences between young and older adults are indicated in bold.*

Habituation Across Time at Low Versus High Elevations

Our results did not reveal a significant interaction of Age, Elevation and Time for any gait outcomes. Significant two-way interactions of Group and Elevation were revealed for gait speed [$F(1,657.8) = 144.01, p < .001, \beta = .182 \text{ m/s}$] (Figure 2), step length [$F(1, 657.4) = 59.6, p < .001, \beta = .096 \text{ m}$], (Figure S1a), step width [$F(1, 658.2) = 11.01, p < .001, \beta = .012 \text{ m}$] (Figure S1b), and double support percentage [$F(1, 301.9) = 46.64, p < .001, \beta = -.049\%$] (Figure 3).

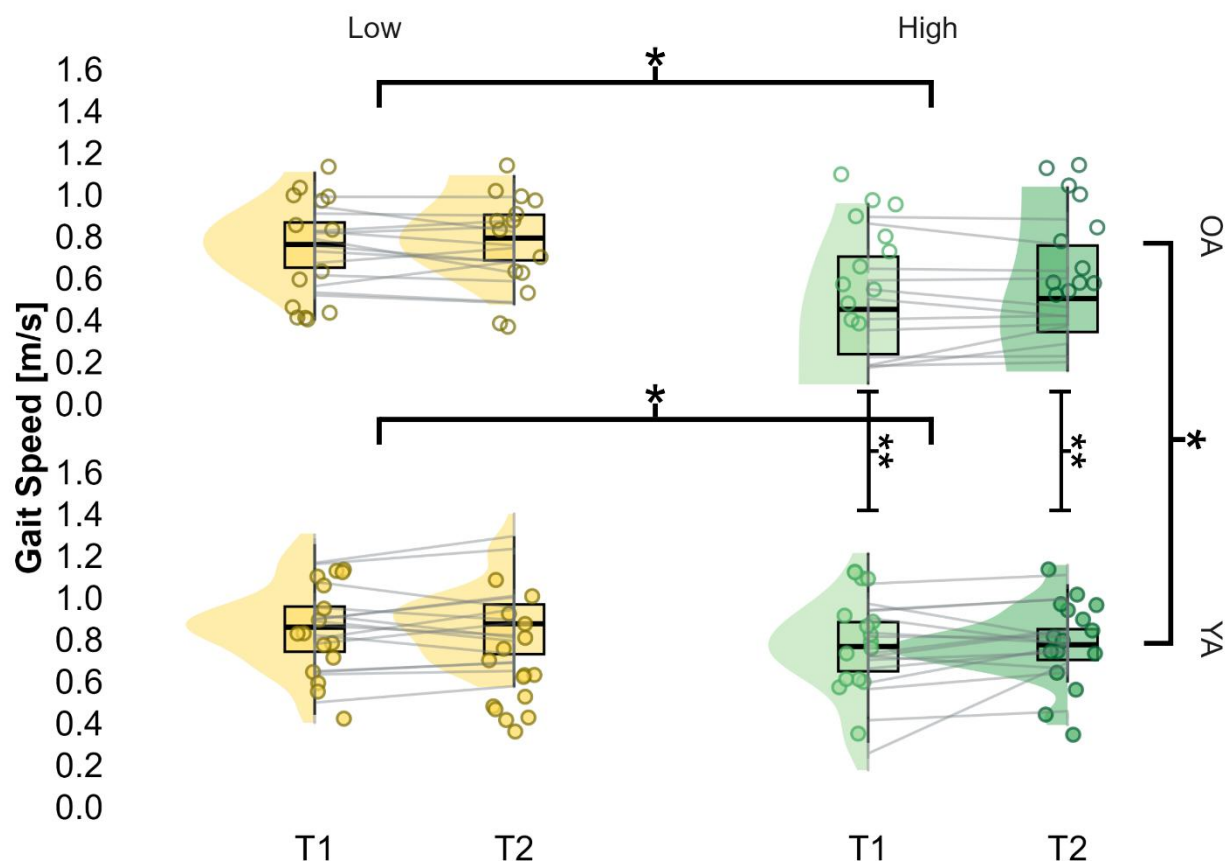


Figure 2: Habituation of gait speed between low and high virtual elevations in young and older adults. Older adult (OA) data is represented in the figures at the top, while young adult (YA) data is in the figures at the bottom. Scattered dots represent

individual data points. Variability of the data is represented by raincloud plots with low VR elevations presented on the left side in yellow and high VR elevations represented on the right side in green. T1 is located on the left side, while T2 is located on the right side of each quadrant of the overall figure. Means are indicated as the solid black horizontal line on the violin plots. Significant differences are represented with asterisks and brackets, where a single asterisk indicates a result of an interaction of age and height, a double asterisk indicates main effects of age, and a triple asterisk indicates main effects of height.

At low VR settings, older adults walked with shorter, [$F(1, 28.0) = 12.42, p = .001, \beta = -.094$ m] wider [$F(1, 28.2) = 6.27, p = .018, \beta = .030$ m] steps compared to young adults.

At high VR settings, older adults walked with slower [$F(1, 26.0) = 13.13, p = .001, \beta = -.284$ m/s], shorter steps [$F(1, 26.1) = 21.39, p < .001, \beta = -.193$ m], and spent more time in double support [$F(1, 26.1) = 7.53, p = .011, \beta = .063$ %], compared to young adults (Figure 3).

Our results also revealed a two-way interaction of Elevation and Time for step length [$F(1, 671.4) = 16.46, p = .012, \beta = -.031$ m]. At low VR settings [$F(1, 341.0) = 10.25, p = .001, \beta = .015$ m] young and older adults walked with significantly longer steps at T2 compared to T1, but at high VR settings participants increased step length more at T2 compared to T1 [$F(1, 319.0) = 83.78, p < .001, \beta = .050$ m].

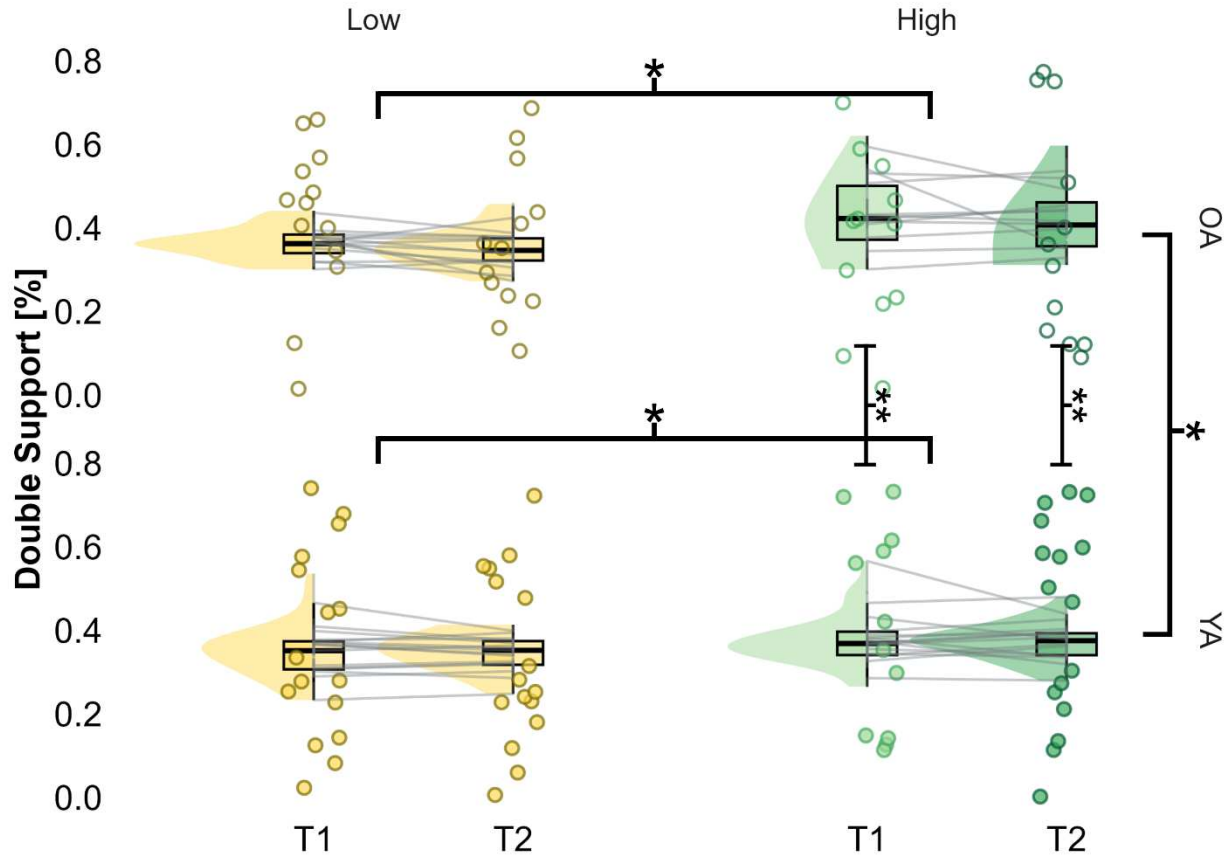


Figure 3: Habituation of double support percentage between low and high virtual elevations in young and older adults Older adult (OA) data is represented in the figures at the top, while young adult (YA) data is in the figures at the bottom. Scattered dots represent individual data points. Variability of the data is represented by raincloud plots with low VR elevations presented on the left side in yellow and high VR elevations represented on the right side in green. T1 is located on the left side, while T2 is located on the right side of each quadrant of the overall figure. Means are indicated as the solid black horizontal line on the violin plots. Significant differences are represented with asterisks and brackets, where a single asterisk indicates a result of a main effect of group and a double asterisk indicates a result of an interaction of age and height.

Age-Related Differences in Habituation to Virtual High Elevations Across Repeated Immersion

Our results did not reveal a three-way interaction of Age, Immersion, and Time for any gait outcomes. Two-way interactions of Immersion and Time were revealed for gait speed [$F(1, 620.7) = 30.91, p < .001, \beta = -.063 \text{ m/s}$] and step length [$F(1, 618.5) =$

32.77, $p < .001$, $\beta = -.034$ m]. Young and older adults walked with significantly longer
[$F(1, 27.0) = 15.50$, $p < .001$, $\beta = .048$ m], faster [$F(1, 26.9) = 7.05$, $p = .013$, $\beta = .052$
m/s] steps at T2 compared to T1 during I1, but not during I2 (Figure 4, Figure S2, Figure
5), suggesting that the majority of gait habituation occurred in the first immersion. Both
young and older adults demonstrated savings between immersions, walking with longer
[$F(1, 26.2) = 21.17$, $p < .001$, $\beta = .057$ m], faster [$F(1, 26.3) = 16.50$, $p < .001$, $\beta = .086$
m/s] steps at T1 of I2 compared to T1 of I1. Although gait speed did not demonstrate
further adaptation in the second immersion, participants walked with longer steps [$F(1,$
25.9) = 9.89, $p = .004$, $\beta = .017$ m] at T2 of I2 compared to T2 of I1. Additionally, there
were no differences in gait speed or step length between T2 of I1 and T1 of I2, further
supporting savings of gait patterns that participants habituated from T1 to T2 in I1
between immersions.

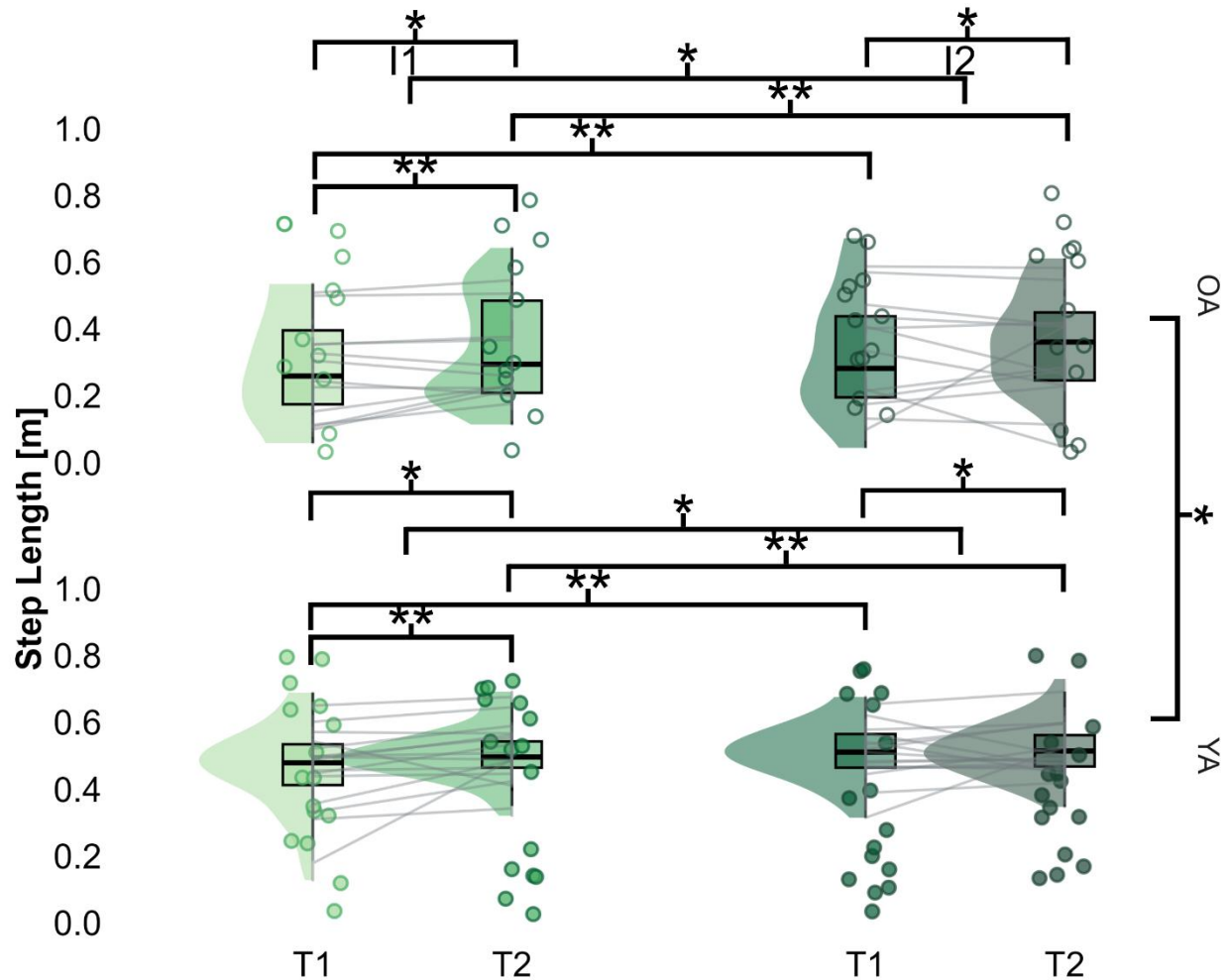


Figure 4: Age-related differences in adaptations of step length to fall-related anxiety over time and savings across repeated exposures. Compensatory changes to step length from the beginning of a five-minute exposure (T1) and the end of an exposure (T2) as well as between the first five-minute exposure (I1) and the second exposure (I2) to anxiety-inducing virtual settings. Older adult (OA) data is represented in the figures at the top, while young adult (YA) data is represented in the figures at the bottom. Scattered dots represent subject means, while variability is represented by the raincloud plots. T1 is located on the left, while T2 located on the right. Significant main effects of group, exposure, and/or time are indicated with a single asterisk and brackets, while significant interaction effects of exposure and time are indicated with a double asterisk.

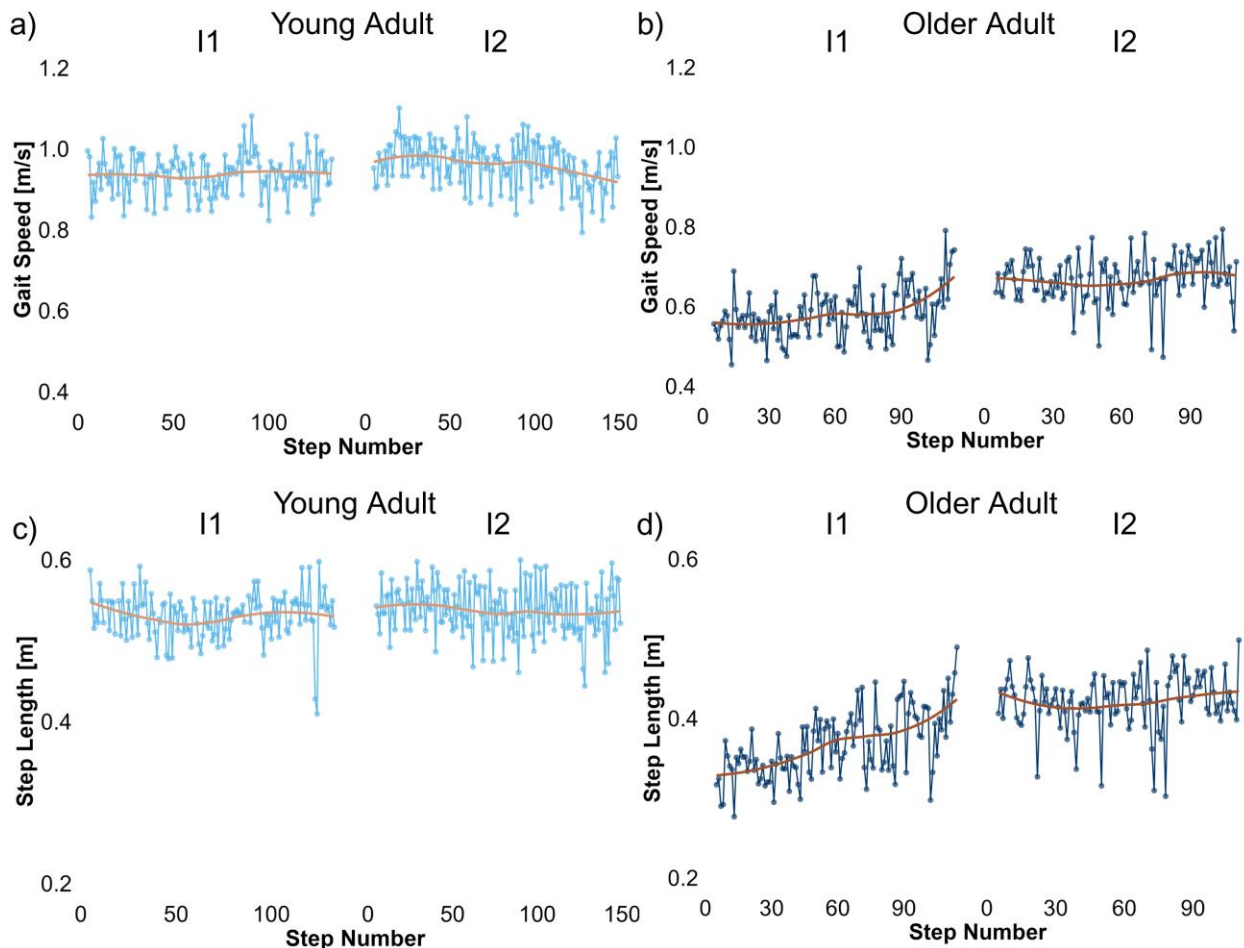


Figure 5(a-d): Sample adaptation time-series graph in representative young adults and older adults. Each graph depicts all steady state steps across time and exposure for a representative participant from each age group. (a) Young adults do not adapt gait speed over time. (b) Older adults increase their gait speed over time. (c) Young adults do not adapt step length over time. (d) Older adults adapt their step length over time.

Preliminary analysis of Heart Rate Variability in a subsample of participants is included in Supplementary Data (Figure S5).

DISCUSSION

We sought to extend research by examining age-related differences in gait habituation at low and high virtual elevations. Our results revealed age-related differences in response to an anxiety-inducing VR environment, however, we did not observe differences in gait habituation. We further sought to determine age-related differences in savings of gait habituation to fall-related anxiety by examining walking performance across repeated immersions to postural threat (i.e. virtual high elevation) in young and older adults. Although we revealed age-related gait differences due to fall-related anxiety, our results revealed that young and older adults exhibited similar savings between immersions.

Habituation to High Elevation Settings

Like previous studies that reported gait habituation with shorter exposures to anxiety-inducing VR settings [17,18], participants in the present study habituated their gait with similar patterns. Young and older adults walked with longer steps over time at low and high elevation settings, indicating no age-specific responses to the anxiety-inducing environment. However, notably, young and older adults walked with faster speeds and increased their step lengths at a greater rate only at high elevations indicating an adaptive response specific to the perceived threat of the anxiety-inducing setting. The specific response to perceived threat may be particularly important, as individuals with excessive concerns of falling or gait impairments may have a limited cognitive motor capacity [1], that could further impair their ability to generate adaptive stepping patterns [9,10].

Additionally, the current methodology differs from typical gait habituation studies [20,35], as the perceived threat drives habituation instead of task constraints. While

other adaptation studies see similar increases in step length [20,21], the increases are due to the inherent step length manipulation of the paradigm. However, in the present study, individuals' step length is not mechanically manipulated, and the use of overground walking methods allows for gait speed changes, therefore, increases in step length and gait speed over time can be attributed to habituation to perceived threat. Additionally, typical fall interventions elicit gait habituation that does not necessarily transfer to daily life [36] due to treadmill use, where the current study's use of overground walking may result in better transfer of habituation to daily life, and therefore better rehabilitation approaches.

Savings of Gait Habituation Between Immersions

Young and older adults walked with wider steps between exposures suggesting that, across ages, individuals save the boundaries of the postural threat (e.g. lateral edges of the walkway), choosing to use other mechanisms to maintain locomotor balance control. However, neither young nor older adults change the amount of time spent in double support, indicating that while step width and length are initially constrained by the perceptions of lateral threat, healthy adults maintain locomotor balance control by sustaining the amount of time spent in stable phases of the gait cycle [37]. Young and older adults instead demonstrate habituation by taking longer steps orthogonal to the direction of the perceived postural threat, in a way that is specific to this paradigm. The continued increase in step length in between immersions indicates savings of motor performance that can be attributed to habituation to the anxiety-provoking environment. We can also attribute the continued increase of step length to optimal habituation strategies under postural threat, as it ensures greater mechanical stability [38] when step width is constrained.

Our results also show that while step length continues to increase across immersions, gait speed does not, suggesting that while gait speed is saved, it is perhaps not saved as robustly. The discontinued increase in gait speed in the second immersion may be an energy saving mechanism that we cannot evoke in treadmill-based paradigms [39]. Walking with slower gait speeds, which our older adults exhibited at the beginning of the immersions, is often associated with increased energy expenditure [39], therefore it is possible that our older adults may have experienced a level of fatigue by the end of the second immersion. In the present study, we use five minutes of adaptive walking, with a one minute washout period, which is shorter than typical split belt procedures that use 10 minutes of adaptive walking followed by 5 minutes of washout [20]. While we use shorter immersions than split belt studies, our immersions represent an average of other studies that investigated the effects of balance due to physical and virtual high elevations [40–42] and gait due to physical [43] and virtual elevations [19,43–45], which range anywhere from 30 seconds to 20 minutes in exposure time and 0.04m to 150m in height. To limit fatigue and maximize habituation benefits, future research is needed to determine an appropriate immersion dosage, in terms of time and height.

Age-Related Differences in Gait During Walking in Virtual Settings

Our results align with previous research investigating age-related differences in walking performance [37,46] where older adults walked with slower, shorter steps and spent more time in double support in response to the anxiety-inducing setting compared to young adults [6]. While age-related differences in gait habituation have been observed in split-belt paradigms [20,21], our results did not reveal age-related differences in anxiety-inducing VR settings. A multitude of factors are attributed to age-

related differences in habituation, such as limited lower limb strength and reduced step propulsion in older age [20,21], as well as concerns of falling [8,37]. It should be noted that the high elevation VR setting specifically manipulates cognitive-motor capacity during exposure by inducing fall-related anxiety that leads to reallocation of attention away from the locomotor task towards rumination [1]. In this context, habituation may be attributed to the limited cognitive capacity due to reallocation of attention at the beginning of the exposure, resulting in young and older adults walking with more cautious gait patterns. Over time, the cautious gait patterns diminish, as participants gain confidence in their ability to maintain locomotor balance control and as cognitive resources are freed from worrisome thoughts, due to reduced perceptions of threat, and reallocated back to posture and gait [11]. Although excessive fall-related anxiety can be maladaptive, appropriate threat responses help maintain balance [47]. While older adults generally have greater concerns about falling compared to young adults [1,2], the older adults in the present study reported low concerns and per the exclusion criteria, had to be generally healthy, therefore, they likely perceived similar threats in the high VR setting compared to the young adults. In general, the low concerns and high physical abilities of this sample, suggest that overall, the responses observed are representative of helpful adaptive responses [1] to fall-related anxiety over time and across repeated immersions.

Limitations and Future Directions

The present study represents a crucial step in understanding age-related differences in gait habituation to fall-related anxiety. However, it is also important to interpret our results with the study's limitations in mind. Although we extend current literature using the VR paradigm to investigate habituation, we recognize that the type

of virtual interface that we used may influence our findings. The head-mounted display provides an opportunity to study overground walking as opposed to treadmill walking which is mechanically different for older adults [48] but inherently limits the users' natural field of vision [49] compared to projection-based environments. Additionally, although we report novel findings of habituation and savings of spatiotemporal gait patterns, measuring mechanical stability would provide insight into potential mechanistic differences in locomotor balance control due to age-related balance impairments. Future studies should incorporate measures such as margin of stability [50] to uncover the mechanisms behind the gait observed. Furthermore, we acknowledge that our population of older adults was high functioning with low concerns of falling, perhaps performing optimally compared to those who would better benefit from this type of intervention (i.e. high fall concerns and low physical function). Future research should investigate the effects of this paradigm on populations with higher concerns of falling and/or with lower levels of physical function.

Conclusion

We identified a lack of age-related differences in gait habituation to VR-induced fall-related anxiety settings, evidenced by increased step length and gait speed over time, regardless of age. Young and older adults exhibited more cautious gait patterns at the beginning of their immersion to postural threat (i.e. high VR elevation) compared to the end of their immersion due to the exposure to fall-related anxiety. Additionally, young and older adults showed savings of habituated motor patterns, but only older adults' savings were associated with decreased physiological arousal, indicating age-specific compensations to fall-related anxiety. Gait habituation to the fall-related anxiety setting may be attributed to increases in cognitive-motor capacity over time in both

young and older adults. The VR paradigm shows potential for its use as a habituation intervention to reduce fall-related anxiety in older adults, as represented in the adaptive and saved locomotor responses coupled with reductions in physiological arousal in this study.

AUTHOR CONTRIBUTIONS

KP: Responsible for funding acquisition, project administration, leading data collection, analysis, and manuscript writing, and VR program development.

QS: Responsible for methodology and guidance on writing, data analysis, and interpretation.

NP: Responsible for methodology and guidance on writing, data analysis, and interpretation.

TJE: Responsible for methodology and guidance on writing, data analysis, and interpretation.

CKR: Responsible for funding acquisition, methodology and guidance on writing, data analysis, and interpretation.

TER: Responsible for conceptualization of the study, funding acquisition and methodology, project administration, VR program development, guidance on writing, data analysis, and interpretation.

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485

486 **Statements and Declarations**

487 The authors have no conflicts to report.

488

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