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Jogging in Your Avatar's Footsteps: The Effects of Avatar Customization and Control Intuitiveness

Minjin MJ Rheu[1]*, *Rabindra Ratan*[2], *Young June Sah*[3], *Leticia Cherchiglia*[2] and *Tom Day*[2]

[1]School of Communication, Loyola University Chicago, Chico, IL, United States, [2]Department of Media and Information, Michigan State University, East Lansing, MI, United States, [3]School of Media, Arts, and Science, Sogang University, Seoul, South Korea

This study examined the effects of customization and intuitiveness of control on the feeling of identification and embodiment, and the actual running performance of game players after playing a digital runner game developed for this research. A 2 (avatar design: customized vs. not customized) × 2 (avatar controls: intuitive vs. not intuitive) within-subjects experiment (N = 44) found that playing the game with a customized avatar increased identification with and embodiment in the avatar. However, using unintuitive controls with a customized avatar diminished the feeling of identification. Customizing an avatar increased identification with and embodiment in the avatar. However, using unintuitive controls with a customized avatar diminished the feeling of identification. Further, participants' running performance was significantly hindered in the customized avatar and unintuitive controls condition, compared to the other conditions. The expectation that identification and embodiment would mediate the effect of avatar customization and control intuitiveness on physical activity was not supported. Together, these results suggest that avatar customization and control intuitiveness should be prioritized when designers intend to use video games to promote post-game physical activity.

Keywords: avatars, embodiment, identification, physical activity, game design for health

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****Correspondence:***
Minjin MJ Rheu
mrheu@luc.edu

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INTRODUCTION

Video games often depict an avatar performing intense physical activity, but little is known about the extent to which such games encourage players to participate in physical activity themselves outside of the virtual world. Although many studies have examined the effectiveness of exergames for promoting physical activity *during gameplay* (Biddiss and Irwin, 2010; Peng et al., 2013), few studies have examined the potential for seated video games to promote exercise or other active behaviors *after gameplay*. The present study addresses this topic, drawing from the Proteus effect, the phenomenon that people conform behaviorally to their avatars' characteristics, even after avatar use (Yee and Bailenson, 2007). This study focuses on the avatar use experience as an element of video games that can be designed intentionally to motivate physical activity after gameplay. Specifically, the present study focuses on how avatar customization and control can be used to harness the Proteus effect in order to facilitate physical activities beyond the gaming context.

Avatar customization and control are notable facets of gameplay because of the way they impact users' psychological connections to their avatars. Avatar customization leads to closer connections between the user and the avatar, and in some cases, avatar customization is nearly as important to players as controlling the avatar itself (Ducheneaut et al., 2009; Turkay and Kinzer, 2015). Similarly, game controls are fundamental to the user's connection to the avatar and also dictate the "feel" and learning curve of the game (Roth et al., 2017; Roth and Latoschik, 2019). These facets of avatar use—customization and control—likely influence players' feelings of identification with and embodiment in an avatar, both of which have been posited as mechanisms of the Proteus effect (Ratan and Dawson, 2016), though little if any empirical research has examined this relationship. The present study offers such a test, utilizing a game developed for this research within an experiment in which avatar customization and control were manipulated and participants' intensity of subsequent physical activity (i.e., running on a treadmill) was measured. Results suggest that avatar customization and control do influence identification with and embodiment in an avatar as expected, but the effects on physical activity were not as predicted. These findings offer implications about game design, especially with respect to avatar customization and control when the design intends to encourage subsequent physical activity.

2 PREVIOUS RESEARCH

Avatar characteristics have been found to influence physical activity in multiple studies. For example, viewing a self-representing (compared to other-representing) avatar exercising in a virtual environment was found to increase participants' exercise activity for up to one full week after viewing the avatar (Fox and Bailenson, 2009). People have been found to exhibit more exercise activity or more positive exercise attitudes after using healthy-weight looking avatars in exercise games compared to overweight or unhealthy looking avatars (e.g., Li et al., 2014; Peña and Kim, 2014; Peña et al., 2016). People who used tough-looking alien-avatar hands blocked more projectiles than players who used normal-looking human-avatar hands (Christou and Michael, 2014). Customizing and using an avatar with greater muscle definition was associated with more physical endurance on a subsequent handgrip exercise task (Lee-Won et al., 2017). Another study found that exaggerated depiction of the flexibility of a body-tracked avatar in a virtual reality exergame increased the feeling of self-presence and performance of the game player (Granqvist et al., 2018).

These findings all relate to the Proteus effect, a phenomenon in which people conform behaviorally to their avatar's characteristics, even beyond avatar use (Yee and Bailenson, 2007; Peña et al., 2009). Studies suggest that this phenomenon occurs across multiple contexts of avatar use with small but reliable effect sizes (Ratan et al., 2020). Most of this previous research has focused on the physical appearance-related characteristics of avatars that induce the Proteus effect, so little is known about what other factors of avatar use might magnify the effect. The present research focuses on avatar customization and controls, two important factors of game design that affect the psychological connection to the avatar and thereby may enhance the extent to which using an avatar in a gaming context increases subsequent physical activity.

2.1 Avatar Customization and Control

Both avatar customization and control have been posited as contributors to the Proteus effect, though direct tests of this expectation are scant. Previous research on avatar customization found that people who customize avatars (compared to those who used randomly assigned avatars) exhibit better performance on a math task for male-avatar users (Ratan and Sah, 2015) and stronger physiological arousal in response to watching their avatar get hit by a sword (Ratan and Dawson, 2016). These studies suggest that avatar customization likely augments the Proteus effect. Similarly, two studies have found that controlling (i.e., feeling embodied in) an avatar—compared to simply watching one—leads to stronger Proteus effects (Yee and Bailenson, 2009; Yoon and Vargas, 2014). Here we note that the comparison of controlling an avatar to watching an avatar lacks ecological validity. By definition, people have control over their own avatars (Nowak and Fox, 2018). However, the extent to which those controls feel intuitive or natural vary based on a variety of factors, such as the way that the controls are designed or the user's background experience. We would expect that controlling an avatar through a control mechanism that is perceived as intuitive would lead to a closer psychological connection with the avatar.

Hence, in the present context, based on the previous research, we would expect that playing a game that depicts a physically active avatar would compel the player to engage in more subsequent physical activity after using a customized (compared to random) avatar and after controlling the avatar with intuitive (compared to unintuitive controls). Because no previous studies on avatar effects of which we are aware have examined avatar customization and control together, there is little evidence on which to base expectations regarding an interaction effect. Customization and control are the two important mechanisms of gameplay that may hinder or boost users' feelings of connection to their avatars and related behavioral outcomes. Further, in real-world settings, we can frequently find conditions where these two mechanisms do not necessarily go hand in hand (e.g., highly customizable avatars with complicated and difficult game controls such as MMORPG games, or non-customizable avatars with easy and intuitive controls such as simple mobile games). On the one hand, the effect may be additive, with a customized avatar with intuitive controls leading to the most physical activity. On the other hand, when using customized avatars, unintuitive controls might be especially frustrating compared to intuitive controls, thereby hindering subsequent physical activity. Given the lack of related research on which to base an expectation, we examine this potential interaction effect through an open-ended research question. Together, our initial hypotheses and research question are as follows:

H1: After playing a game that depicts a physically active avatar, players will exhibit more physical activity if they **1)** used a customized (compared to random) avatar, and **2)** used intuitive (compared to unintuitive) avatar controls.

RQ1: In a game that depicts the avatar being physically active, does control intuitiveness moderate the effect of avatar customization on post-game physical activity?

Although previous studies offered consistent explanations that avatar customization and control influences psychological or behavioral outcomes (e.g., attitudes or health behavior) *via* psychological closeness to the avatar which is facilitated by those facets of avatar use, they did not provide empirical tests of this process. Here we delve into some possible mechanisms that seem likely to cast some light on the matter, namely identification with and embodiment in an avatar.

2.2 Identification and Embodiment

Avatar customization, a fundamental aspect of many video games (Ducheneaut et al., 2009), facilitates identification with avatars as evidenced by changes in participants' psychophysiological activity, such as heart rate and arousal (Ratan and Dawson, 2016), as well as self-reported identification with the game character (Van Looy et al., 2012; Turkay and Kinzer, 2015) after using customized compared to generic avatars. Though rooted in research on text-based media (Cohen, 2001), previous research on digital games and virtual words has applied the concept of identification numerous ways. Recently, researchers have hotly debated definitions of identification with avatars (Bowman et al., 2020; McDade-Montez and Dore, 2020). Here, identification is considered to be a shift in media users' self-concept to include aspects of an avatar's characteristics (Klimmt et al., 2009; Downs et al., 2019). Identification is influenced by many factors—such as game narratives (Christy and Fox, 2016), the similarity of the avatar's appearance to self (Trepte and Reinecke, 2010; Waltemate et al., 2018), and the amount of time spent using the avatar (Song and Fox, 2016)—though the present study focuses on avatar customization as the primary cause. Customization of an avatar involves selecting various characteristics of an avatar—such as gender, appearance, costumes, etc., (Ratan and Dawson, 2016)—and can be done in various ways. Game players may customize their avatars to look similar to themselves or different from themselves, as they can explore diverse possible selves through an avatar (Bargh et al., 2002; Przybylski et al., 2012). Also, they may spend significant time customizing their avatars meticulously or simply choose some aspects of their avatar from existing options. In the present study, avatar customization is assumed to involve projecting oneself into the avatar during the process of customization, which is thought to create a psychological connection between the user and the avatar.

This study also focuses on avatar control, which is expected to directly influence feelings of embodiment in an avatar, as another important facet of avatar use that is closely related to identification with an avatar (Van Looy et al., 2012). Although "embodiment" has been used to denote different meanings in the literature (Biocca, 1999; Haans and IJsselsteijn, 2012; Fox et al., 2013; Kim et al., 2014), here we treat it as the perception of bodily integration with an avatar (Biocca, 1999). Having greater control over an avatar increases embodiment in an avatar by helping users develop a sense that the avatar's movements are a natural extension of the user's own body schema (Roth et al., 2017; Roth and Latoschik, 2019), a feeling that could be referred to as body ownership or self-presence (Ratan, 2013). Hence, we would expect that using intuitive or familiar controls—compared to controls that are novel or complex—would lead to more embodiment in an avatar.

Thus far, we have developed the logic to predict two associations—avatar customization leads to identification and avatar control leads to embodiment—both of which are well-supported by the literature. The present study also examines the crossed associations—avatar customization with embodiment, avatar control with identification—on which there is less previous research. Regarding the former, because customization has been found to increase identification and embodiment has been conceptualized as a subconstruct of identification (Van Looy et al., 2012; Turkay and Kinzer, 2015; Ratan and Dawson, 2016), then customization should increase embodiment. Conversely, using intuitive or natural avatar controls—compared to controls that are novel or complex—may enhance the extent to which the avatar can be used to manifest the user's agency, thereby facilitating the integration of the avatar's characteristics into self-concept (i.e., identification). The hypotheses following this logic are articulated as follows.

H2: When people use an avatar they have customized—compared to a random avatar—they experience more **1)** identification and **2)** embodiment with the avatar.

H3: When people control an avatar using an intuitive—compared to an unintuitive—control scheme—they experience more **1)** identification and **2)** embodiment with the avatar.

Given this logic, there is reason to believe that there is an additive interaction effect between avatar customization and avatar control on identification with and embodiment in an avatar: using a customized (compared to randomly assigned) avatar with intuitive (compared to unintuitive) controls should lead to the most identification and embodiment while using a random avatar with unintuitive controls would do the opposite. However, alternative patterns might be possible. For example, using unintuitive controls (compared to intuitive controls) might increase feelings of investment in an avatar, which could lead to more identification when using random avatars. Given the dearth of related research on such interaction effects, we explored these effects through open-ended research questions.

RQ2: Does the interaction between avatar customization and control intuitiveness influence perceived **1)** identification and **2)** embodiment?

Further, if the previous expectations are supported, this would suggest that identification with and embodiment in an avatar are indeed mechanisms of the Proteus effect—as previously proposed

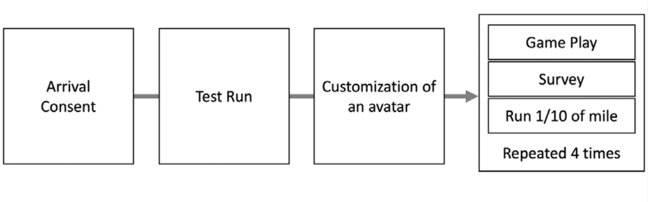

FIGURE 1 | Experimental procedure.

FIGURE 2 | NeuroRunner gameplay screen.

(Ratan and Dawson, 2016)—that can be used for game design to increase players' subsequent physical activity. The feelings of identification and embodiment, boosted by customization and intuitive control, may facilitate the players' physical activity after the game play. However, to provide further evidence that this is the case, identification and embodiment should at least partially mediate the effects of avatar customization and control on subsequent physical activity. Hence, we propose:

H4: The effects of avatar customization and avatar control intuitiveness on users' subsequent physical activity are mediated by **1)** identification and **2)** embodiment.

3 METHODS

3.1 Participants and Design

College students (N = 44, 19 male, 25 female) from a large Midwestern university were recruited to participate in this 2 (avatar design: customized *vs.* randomly-given) ×2 (control scheme: intuitive *vs.* unintuitive) within-subject experiment (**Figure 1**). We selected this design to explore the interactive effects of these two conditions. All participants were between 18 and 24 years old, 23 were White (52.3%), 16 were Hispanic/Latino (36.4%), four were of African descent (9.1%), and one was Native Hawaiian or Pacific Islander (2.3%). They received a small amount of extra credit in their classes for participating in the IRB-approved study.

3.2 Stimuli

A digital runner game named *NeuroRunner,* created by the research team with Unity 3D, was used as the experimental stimuli to manipulate the avatar design and control scheme conditions. Players used four buttons to control the character's horizontal and vertical movements in order to avoid obstacles while running forward (**Figure 2**). One playthrough took approximately 4 min, with eight different levels taking 30 s each. To account for participants' skill acquisition throughout gameplay, each level advanced in difficulty by increasing the rate at which obstacles appeared. After playing through the whole 4-min game, participants were asked to confirm that they were feeling fine to the researcher (who was sitting in a partitioned area of the room and could not see the participant or computer screen) before proceeding.

Running into an obstacle slowed the avatar down for a moment. At the end of each level was a checked finish line, but the gameplay paused after 30 s regardless of whether the participants made it there (in order to ensure equal timing per level between participants). This style of game is appropriate for this research because running is a natural physical activity, the ability to view the character's body throughout the game potentially facilitates feelings of identification (Black, 2017), and the ability to control the character's movement potentially facilitates feelings of embodiment (Roth and Latoschik, 2019).

TABLE 1 | Unintuitive control schemes for each set of levels.

Set	Left	Right	Jump	Slid
2	W	Q	O	P
3	W	Q	P	O
4	O	P	W	Q
5	P	O	W	Q
6	P	O	Q	W
7	P	W	O	Q
8	O	Q	P	W

3.3 Manipulation

For the customized avatar condition, participants played the game with the character they had customized. For the random avatar condition, participants played the game with a character that displayed randomly selected colors. Each subsequent time the participant was in this condition, a new avatar was randomly generated to prevent the participant from feeling familiar with a random avatar. The game was coded to ensure that these randomly generated avatars were never identical to the participant's own customized avatar (**Figure 3**).

For the intuitive control condition, the controls were as follows: Q—move left; W—move right; O—jump; P—slide. These specific keys were chosen so that the participants would be forced to use both hands while controlling the avatar, which was an essential element of the game design in preparation for future studies (planned to be conducted within an fMRI device). In this condition, the avatar's movement was naturally mapped to the location of each of the controller keys. For example, Q is located on the left side of W, and these two keys were used to move the avatar to the left or right.

For the unintuitive-control condition, the controls were scrambled with increased difficulty in each of the eight levels (**Table 1** for detailed configuration). For example, the controls inverted horizontal movement (right and left), with Q used for right instead of left, and W used for left instead of right. As participants proceeded to more difficult levels, the controls added an inversion to the vertical movement (jump and slide).

Constant changes in control schemes in the unintuitive condition were intended to ensure that participants did not get familiar with the *unintuitive* controls and keep the manipulation effective throughout the gameplay. Playtesters with significant experience gaming confirmed the increasing difficulty of these unintuitive control schemes.

The conditions were administered in a balanced and rotated order with six possible orderings. Participants always started with the customized avatar and intuitive control condition to ensure that they were familiarized with their own character and the intuitive controls. The second through fourth runs contained the other three conditions (i.e., own avatar and unintuitive controls; random avatar and intuitive controls; and random avatar and unintuitive controls) in rotated order so that potential ordering effects could be mitigated. Specific orderings were randomly assigned between subjects. We conducted repeated ANOVA with the orderings included as between-subject variable. The test of between-subject effects was not found to be significant, $F\,(5, 38) = 1.78$, $p = 0.14$. Therefore, the between-subject variable was excluded in the following analysis.

3.4 Procedure

Participants were asked to come to the lab wearing gym attire (e.g., running shoes and comfortable clothing). Upon arrival, participants signed a consent form and completed a short questionnaire about their average amount of weekly physical activity and previous experience with exergames. After completing the survey, participants completed a one-minute test run in order to ensure that they were comfortable with the study procedure. After the test run, participants were asked to customize an avatar to represent their own identity. Participants were given instructions on how to play *NeuroRunner* and then they played a short tutorial. In addition to the basic mechanics of the game, they were told the controls would sometimes change during gameplay and they should do their best to continue as normal.

Once participants were assured they understood game controls and rules, they began the main session where they went through all four conditions. In each condition, participants first played the runner game for approximately 4 min. After playing the game, they completed a short survey asking the extent of identification with and embodiment in their avatar felt during gameplay. Then, participants were asked to run on a manual (no motor) treadmill for 1/10 of a mile. Participants were told to stop when they had reached 1/10 of a mile by the researcher, who was measuring the distance and time from the partitioned area of the room. After the running was complete, the researcher recorded the time it took for the participant to reach 1/10 of a mile. Participants repeated the main session four times, one for each condition.

3.5 Measures

3.5.1 Seconds of Running

The researcher recorded the duration of each participant's running using a stopwatch. Participants were asked to start running on a count of three. The researcher began recording the time by hitting the start button on the stopwatch and they stopped recording at the moment participants reached 0.1 miles, according to the treadmill monitor. A shorter duration of running implies a faster running speed, which would require more energy being put into the manual (no motor) treadmill.

3.5.2 Identification

This measure was derived from existing measures of identification and related concepts (Van Looy et al., 2012; Ratan, 2013). Participants indicated their agreement on 5-point Likert scales to eight items, including, "The character's appearance reflected my identity," "I identified with the character's appearance," and "I felt disconnected from the character's appearance," (reverse coded). A composite score was created from the average of these items ($\alpha = 0.88$).

3.5.3 Embodiment

This measure was also derived from existing measures of embodiment and related concepts (Van Looy et al., 2012; Ratan, 2013). Participants indicated their agreement on 5-point Likert scales to eight items, including, "The character felt like an extension of my body," "I was inside the character," and "I felt like I became one with the character," and "I felt like I acted directly through the character." A composite score was created from the average of these items ($\alpha = 0.97$).

4 DATA ANALYSIS AND RESULTS

4.1 Tests for Effects on Physical Activity

Results of a repeated-measures ANOVA with seconds of running as the dependent variable showed that the main effect of avatar type was not significant, $F\,(1, 40) = 0.72$, $p = 0.40$. The main effect of control intuitiveness was close, but did not meet the statistical significance, $F\,(1, 40) = 3.83$, $p = 0.06$. The interaction between avatar type and control intuitiveness was significant, $F\,(1, 40) = 6.62$, $p = 0.02$ (**Figure 4**; **Table 2** for *Ms* and *SDs* for all dependent variables in each condition).

Probing the interaction, a pairwise comparison of estimated marginal means between each condition revealed that there was a significant difference between natural and unnatural controls when a customized avatar was used, $F\,(1, 43) = 6.62$, $p = 0.01$, $\eta_p^2 = 0.13$. Specifically, when using a customized avatar, participants ran faster after they used the natural controller,

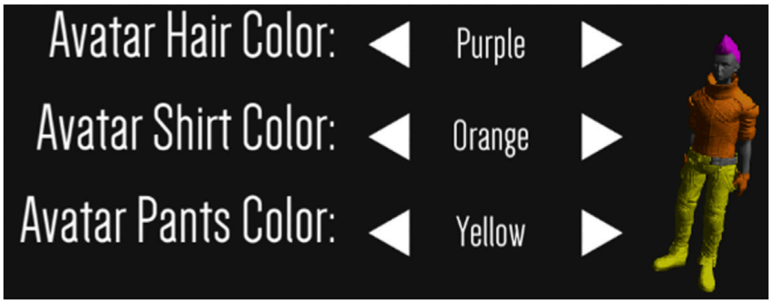

FIGURE 3 | NeuroRunner avatar customization screen.

TABLE 2 | Means and standard deviation for dependent variables in each condition.

Condition	Customized avatar, intuitive control		Customized avatar, unintuitive control		Random avatar, intuitive control		Random avatar, unintuitive control	
	M	SD	M	SD	M	SD	M	SD
Identification	3.19	0.49	2.92	0.77	2.15	0.61	2.19	0.68
Embodiment	2.07	0.95	2.09	1.05	2.01	0.99	1.74	0.92
Running Speed	96.73	28.82	105.61	32.81	98.55	31.75	100.32	29.99

M_{est} = 96.73, *SE* = 4.35, 95% CI [87.97, 105.49], as compared to the unnatural controller, M_{est} = 105.61, *SE* = 4.95, 95% CI [95.64, 115.59]. When a randomly assigned avatar was used, there was no statistically significant difference in the running seconds between the natural, M_{est} = 98.55, *SE* = 4.79, 95% CI [88.89, 108.20], and unnatural controls, M_{est} = 100.32, *SE* = 4.52, 95% CI [91.20, 109.44]. Further, when the unnatural control was used, there was a significant difference in the running seconds between the two avatar types. Participants ran faster after they played the running game using the unnatural control and a random avatar, M_{est} = 100.32, *SE* = 4.52, 95% CI [91.20, 109.44], than after using the unnatural control and a customized avatar, M_{est} = 105.61, *SE* = 4.95, 95% CI [95.64, 115.59]. When using the natural control, participants running seconds did not differ significantly between the customized avatar condition, M_{est} = 96.73, *SE* = 4.35, 95% CI [87.97, 105.49], and the random-avatar condition, M_{est} = 98.55, *SE* = 4.79, 95% CI [88.89, 108.20].

These results provide no support for H1a (more physical activity after using a customized compared to random avatar) and partial support for H1b (more physical activity after using intuitive compared to unintuitive avatar controls). Most notably, the results provide insight into Research Question 1 (Does control intuitiveness moderate the effect of avatar customization on post-game physical activity?). Specifically, participants in the own-avatar, unintuitive-controls condition ran slower than participants in all other conditions, suggesting that these facets influence the Proteus effect in an interconnected, previously untheorized way (discussed below).

4.2 Tests for Effects on Identification

A repeated-measures ANOVA revealed that the main effect of avatar type on identification was significant, $F\,(1, 43) = 95.12$, $p <$

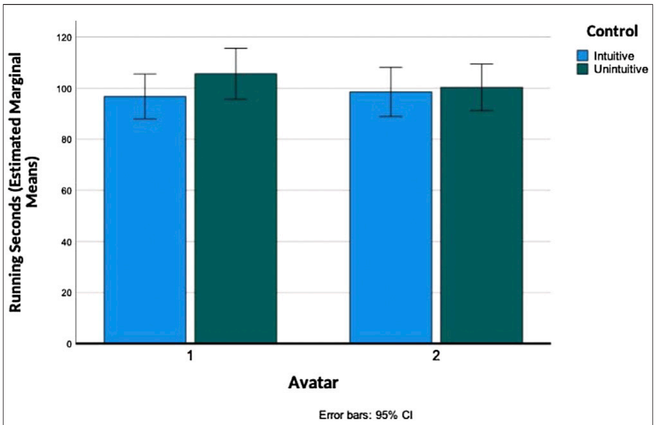

FIGURE 4 | Estimated marginal means of run time in seconds.

0.001, $\eta_p^{\,2}$ = 0.69. Overall, the customized avatar led to greater identification, *M* = 3.06, *SE* = 0.08, than the randomly-given avatar did, M_{est} = 2.17, *SE* = 0.08, 95% CI [2.00, 2.34]. The main effect of control type was not significant, $F\,(1, 43) = 2.02$, $p = 0.16$. There was an interaction between avatar type and control scheme on identification, $F\,(1, 43) = 5.67$, $p = 0.02$, $\eta_p^{\,2}$ = 0.12 (**Figure 5**).

Probing the interaction, when using a customized avatar, there was a significant difference between natural and unnatural control, F (1, 43) = 5.83, p = 0.02, $\eta_p^{\,2}$ = 0.12. Identification was higher when using a customized avatar and intuitive control, M_{est} = 3.19, *SE* = 0.07, 95% CI [3.04, 3.34], than when using a customized avatar and unnatural control, M_{est} = 2.92, *SE* = 0.12, 95% CI [2.69, 3.16]. However, when using a randomly assigned avatar, there was no difference in identification regardless of the

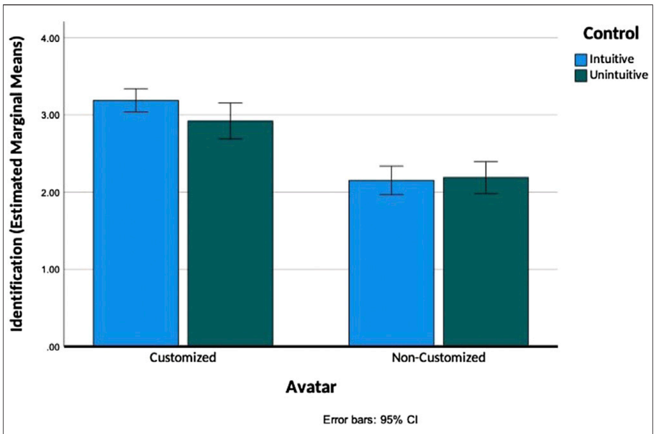

FIGURE 5 | Estimated marginal means of identification.

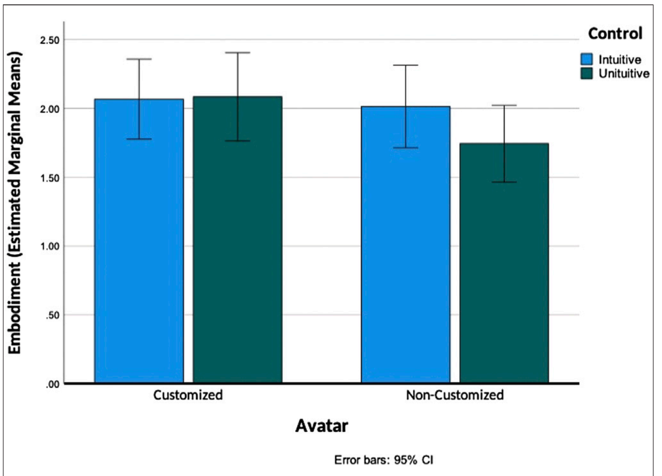

FIGURE 6 | Estimated marginal means of embodiment.

intuitive, $M_{est} = 2.15$, $SE = 0.09$, 95% CI [1.97, 2.34], or unintuitive control schemes, $M_{est} = 2.19$, $SE = 0.10$, 95% CI [1.99, 2.40].

These results support H2a (using a customized—compared to a random—avatar leads to more identification) and provide insight into RQ2a (does the interaction between avatar customization and control intuitiveness influence perceived identification). Namely, unnatural control significantly undermined the effect of customization on the identification with the avatar. Although the main effect of control on identification was not found, this interaction effect suggests that control intuitiveness does influence identification, at least when using a customized avatar, thereby providing partial support for H3a (When people control an avatar using an intuitive—compared to unintuitive—control scheme, they experience greater identification).

4.3 Tests for Effects on Embodiment

Avatar type and control type were also found to influence embodiment. The main effect of customization on embodiment was significant, F (1, 43) = 4.13, $p = 0.05$, $\eta_p^2 = 0.09$. The customized avatar led to greater embodiment, $M_{est} = 2.08$, $SE = 0.14$, 95% CI [1.78, 2.36] than the random-avatar, $M_{est} = 1.88$, $SE = 0.14$, 95% CI [1.61, 2.15]. Unexpectedly, the main effect of control type on embodiment was not significant, F (1, 43) = 2.24, $p = 0.14$. However, we found a significant interaction effect between customization and control on embodiment, F (1, 43) = 4.57, $p = 0.04$, $\eta_p^2 = 0.10$ (**Figure 6**). This difference appears to be mainly driven by the random-avatar unintuitive-control condition in which embodiment was the lowest, $M_{est} = 1.75$, $SE = 0.14$, 95% CI [1.47, 2.02] while embodiment was quite similar in the customized-avatar intuitive-control condition, $M_{est} = 2.07$, $SE = 0.15$, 95% CI [1.78, 2.36], customized-avatar unintuitive-control condition, $M_{est} = 2.09$, $SE = 0.16$, 95% CI [1.77, 2.41] and other-avatar intuitive-control condition, $M_{est} = 2.01$, $SE = 0.15$, 95% CI [1.71, 2.31]. Probing the interaction, a series of simple-effects tests suggest that the mean differences for each of these three comparisons were statistically significant at the $p < 0.01$ level.

The results support H2b (using a customized—compared to a random—avatar leads to more embodiment) and provide insight into RQ2b (does the interaction between avatar customization and control intuitiveness influence perceived embodiment?). Namely, unintuitive control of a random avatar hinders embodiment significantly, while both intuitive controls *or* avatar customization were found to lead to higher levels of embodiment. Although the main effect of control intuitiveness on embodiment was not found, this interaction effect suggests that control intuitiveness does influence embodiment (negatively) when using a random avatar, thereby providing partial support for H3b (When people control an avatar using an intuitive—compared to unintuitive—control scheme, they experience greater embodiment).

4.4 Tests for Mediation Effects

Finally, in order to test the hypotheses regarding mediation, we conducted a repeated-measures mediation analysis using SPSS and the MEMORE v2.1 macro (Montoya, 2019). This software allows for a comparison of two repeated conditions, so we chose the conditions that exhibited patterns consistent with the expectations regarding mediation. Namely, within the customized avatars, intuitive controls (compared to unintuitive controls) were found to reduce subsequent running seconds as well as identification. Hence, identification was tested as a mediator of control intuitiveness within the customized avatar condition. This test did not yield significant results (95% CI, LLCI = −4.30, ULCI = 2.21). Similarly, for the test of embodiment as a mediator, we focused on the unintuitive controls condition, within which customized avatars led to higher running seconds and higher embodiment. However, embodiment was not found to mediate the effect of avatar customization on running speed (95% CI, LLCI = −1.77, ULCI = 2.35). Together, these tests provide no support for H4a (The effects of avatar customization and avatar control intuitiveness on users' subsequent physical activity are mediated by identification) or H4b (The effects of avatar customization and avatar control intuitiveness on users' subsequent physical activity are mediated by embodiment).

5 DISCUSSION

This study examined avatar customization and control as elements of video games that can be designed intentionally to motivate post-gameplay physical activity through the Proteus effect, the phenomenon that people tend to conform behaviorally to their avatars' characteristics, even after avatar use (Yee and Bailenson, 2007). Participants' running performance on a treadmill after playing an avatar-running game was influenced by the interaction between using a customized avatar (compared to random avatar) with intuitive controls (compared to unintuitive controls). Participants in the customized avatar, unintuitive controls condition ran slower than all other conditions. The interaction between avatar customization and control intuitiveness—as well as the main effect of avatar customization—were found to influence feelings of identification with and embodiment in the avatar. However, the expectation that identification and embodiment would mediate the effect of avatar customization and control intuitiveness on running speed was not supported. Hence, in sum, these results suggest that avatar customization and control intuitiveness do affect both post-game physical activity as well as identification and embodiment, but this study does not offer evidence that identification and embodiment are a mechanism in the effect on physical activity.

This study's most notable finding relates to the effect on post-game physical activity. Using a customized avatar with unintuitive controls significantly reduced participants' post-game physical activity in comparison to the other conditions: customized avatar with intuitive controls, a random avatar with intuitive controls, and random avatar with unintuitive controls. In these latter three conditions, running speeds were similarly high compared to the customized avatar, unintuitive controls condition. Although somewhat consistent with the expectation that intuitive controls facilitate faster post-game running, this finding seems better interpreted as an effect of unintuitive controls *hindering* post-game running, but only in the customized condition. Why would this be? One interpretation is that avatar customization leads to a closer connection with the avatar (e.g., identification), but unintuitive controls interfere with this connection. Unintuitive control made the avatar fall at obstacles more often and consequently slowed down its running speed in the game, thereby preventing the Proteus effect from occurring. On the contrary, in the intuitive control condition, participants were better at controlling the avatar and therefore the avatar's running was not hindered by obstacles, thereby facilitating the Proteus effect. Although the interaction pattern found for identification is consistent with this logic, the expectation that identification mediates the relationship on post-game running speed was not supported.

One alternative explanation is that because customization led to high identification, unintuitive controls were especially frustrating for the player. In other words, at first, they felt a strong connection to the avatar (*via* customization), but then this connection was severed due to the unintuitive controls, leading to a sense of frustration or disappointment. Or similarly, perhaps participants felt more motivated to perform well in the game when using a customized avatar, but the unintuitive controls required more focus and effort, which was mentally tiring. In either case, the increased frustration or mental effort in this condition could have diminished the amount of energy participants felt comfortable expending on the subsequent running activity. Although these explanations are speculative and the present findings do not offer evidence of which explanation(s) are at play, they do raise this important question for future research, which could include subjective measures of frustration and mental effort when examining the influence of avatar control on post-game physical activity.

The finding that avatar customization increases identification is unsurprising, but the interaction effect with control intuitiveness offers new insights into identification. Namely, when using a customized avatar, the intuitive controls led to significantly more identification than the unintuitive controls, while in the random avatar condition, control intuitiveness did not make a difference in identification. Looking at this pattern of interaction (**Figure 4**), customization clearly has a stronger effect on identification than control intuitiveness. Hence, it seems more appropriate to interpret this interaction effect as a function of the unintuitive controls *hindering* identification rather than the intuitive controls bolstering it. In other words, people feel closely identified with their avatar after customizing it, but then if the mechanisms to control the avatar are unintuitive, the connection with the avatar is diminished, leading to less identification. This is a novel finding that suggests an effect of avatar control on identification with avatars.

This is consistent with a recent study which found that perceived interactivity, defined as degree of control over media content, influences the feeling of connection to story characters (Pimentel et al., 2021). This finding supports the notion that the extent to which user inputs correspond with expected character outputs (e.g., movements) facilitates users' psychological engagement with their virtual character, whether it be a game avatar or a protagonist in an interactive narrative. Importantly, this could happen in the opposite direction, such that the level of psychological engagement with the character may bolster the perceived interactivity of a system (Jin, 2009). Taken together, it is reasonable to expect that the level of identification and perceived interactivity of an interface may positively influence each other.

The findings for embodiment offer an interesting complement to those for identification. Namely, customization appears to play a larger role in embodiment than expected, while control intuitiveness only influenced embodiment as a moderator of the customization effect, which was unexpected. Specifically, when using a random avatar, the intuitive controls led to significantly more embodiment than the unintuitive controls, while in the customized avatar condition, control intuitiveness did not make a difference in the feeling of embodiment. Looking at this pattern of interaction (**Figure 5**), control intuitiveness does not seem to influence embodiment for customized avatars, suggesting that avatar customization leads to a level of embodiment that is robust to differences in control intuitiveness. In contrast, when using a random avatar, the level of the embodiment is approximately the same as when using a customized avatar *if the controls are intuitive*, but if the controls are unintuitive, the feeling of embodiment drops. In other words, the interaction effect appears to be driven by a single condition: people who used a random avatar with unintuitive controls. This suggests that avatar control is a less important facet of embodiment than expected, while avatar customization is more important than expected.

In summary, this study's findings suggest that avatar customization can facilitate physical activity after gameplay as well as the feelings of identification with and embodiment in one's avatar, but unintuitive controls may interrupt these connections. Although we did not find any evidence of identification or embodiment mediating the effect of customization and control on running after gameplay, the present study was potentially unable to capture such a relationship due to issues of study design (e.g., within-subjects, repeated measures). Future research should continue to examine the potential that identification and embodiment—or other facets of the psychological connection to avatars—facilitate post-game physical activity, keeping in mind that (and measuring for) other facets of gameplay (e.g., frustration, mental effort) may also play a role.

5.1 Practical Implications

One goal for this research was to identify practical ways in which avatar-use experiences in games can be utilized to increase post-game physical activity *via* the Proteus effect. Just as experiences in video games influence other types of post-game behavior—for example, cooperative play increases post-game prosocial behavior (Velez and Ewoldsen, 2013; Dolgov et al., 2014)—the intense physical activity depicted in many video games could potentially be designed to increase players' post-game physical activity. Of course, there are many factors to consider regarding post-game physical-activity effects (e.g., video games tend to be a stagnant activity). Holding other such factors constant, the present research suggests that avatar customization contributes to the likelihood that users will emulate the physical activity they see their avatars performing in the video game. Further, intuitive controls are essential to this phenomenon as unintuitive controls diminish the effect on physical activity, especially for customized avatars, according to the present findings. This suggests that if designers intend for a video game to cause post-gameplay physical activity, they should build in a platform for players to customize their avatars and also prioritize providing control mechanisms that are intuitive or otherwise easy to learn. This could engender the optimal feeling of embodiment or body ownership as well as motivate physical activity. Further, using more advanced techniques such as first-person perspective or synchronized movement through a virtual representation for this type of game may create the illusion of body transfer (Slater et al., 2010), which may heighten the feeling of identification and/or Proteus effect.

In addition, for those who are not familiar with game-playing, controlling their avatar could be an obstacle for enjoyment and continued use of the game. In this sense, the study results imply that it is important to flatten the learning curve for newer gamers. This is consistent with other research suggesting that user experiences are improved through avatar customization (Birk and Mandryk, 2018) and controller naturalness (Seibert and Shafer, 2018; Hufnal et al., 2019).

5.2 Limitation

This study is not without limitations. Embodiment was not found to influence the Proteus effect as expected, possibly due to the inability of the study materials (e.g., a flat screen monitor) to effectively produce a sufficient sense of embodiment. Future research could employ other technologies of self-mediation that facilitate greater feelings of embodiment (e.g., virtual reality, haptic feedback). Also regarding the study materials, the mechanism for customizing the avatar was quite rudimentary—the choice of a few simple colors. Although having this basic of choices was found to strongly increase identification with the avatar, it is possible that a more advanced customization platform would lead to different results. Given the complexity of developing avatar-customization platforms, future research might be better suited to test such questions by using commercial games as stimuli.

Another issue is that the methods used to promote an association between participants and their avatars in this study (i.e., customization and control intuitiveness) are certainly not the only ways to enhance avatar identification and embodiment and might not be the best ways to do so. Avatar customization strategies are diverse and contextual, and therefore, different avatar customization methods may impact the feelings of identification and embodiment differently (McArthur, 2019). Therefore, it is important to investigate numerous avatar design strategies to boost avatar identification and embodiment to augment the post-play effects. Other ways to reinforce avatar identification and embodiment might depend on the media types (e.g., games, virtual reality) and contexts of use (e.g., education, health, and persuasion).

Regarding the measure of physical activity, we used *seconds of running* as a proxy to represent participants' level of physical activity. One limitation of this measure is that participants were likely to have different levels of fitness, causing noise in this data. Future research could address this by measuring and controlling baseline speed or fitness. Further, physiological measures such as heart rate could be used to measure exertion and to corroborate non-physiological data that indicate physical activity.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article are available here: https://osf.io/3dfqa/.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Michigan State University Human Research Protection Program, Office of Regulatory Affairs. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

MR collected and analyzed the data and made a major contribution in writing the manuscript. RR conceptualized the study, designed the experiment, and made a major contribution in writing the manuscript. He also supervised the entire study. YS participated in writing manuscript and provided advice on the theoretical frameworks of the study. LC and TD participated in experiment design and data collection. All authors read and approved the final manuscript.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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