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HOMEX: Persuasive Technology Acceptance Model and the Moderating Effect of Culture

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The number of fitness applications on the market is increasing annually, driven by the increasing awareness of the need to support and motivate physical activity to reduce the incidence of non-communicable diseases worldwide. However, there is limited research on the user-experience (UX) design attributes that drive their adoption and the moderating role culture plays. Consequently, we conducted a study on the Persuasive Technology Acceptance Model (PTAM) for a fitness application aimed at motivating physical activity at home. Using Canada (an individualist culture, $n = 189$) and Nigeria (a collectivist culture, $n = 67$) as a case study, we investigated: (1) which of the commonly researched UX design attributes (*perceived aesthetics*, *perceived usability*, *perceived credibility* and *perceived usefulness*) have the strongest influence on users' *intention to use* a fitness application; (2) the moderating effect of culture; and (3) how *perceived persuasiveness* mediates the direct effect of *perceived usefulness* on the *intention to use* a fitness application. The results of our path analysis show that, regardless of culture, *perceived usefulness* and *perceived aesthetics* are the strongest determinants of users' *intention to use* a fitness application, with *perceived usefulness* being stronger in the collectivist culture than in the individualist culture. Secondly, our results show that *perceived persuasiveness* partially mediates the effect of *perceived usefulness* on *intention to use* for the individualist culture, but not for the collectivist culture. Hence, we recommend that designers should invest more in improving functionality (utilitarian benefit) and aesthetics (hedonic benefit) than other UX design attributes such as credibility and usability. However, for the collectivist culture, designers should focus more on *usefulness* than *aesthetics*. On the other hand, for the individualist culture, designers should strike a balance between *usefulness* and *aesthetics*. Our main contribution is that, our study, to the best of our knowledge, is the first to investigate the moderating effect of culture using subjects from North America and Africa (an understudied population) as a case study.

Keywords: persuasive technology, fitness application, user experience, design attributes, perceived usefulness, perceived aesthetics, TAM, culture

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INTRODUCTION

Fitness applications have permeated the lives of many people around the world as a result of the need for humans to be and remain healthy physically and mentally, particularly, to slow down the inevitable effects of aging. Fitness applications have become popular because of the increasingly sedentary lifestyles, often resulting in overweight, obesity, and non-communicable diseases such as type-2 diabetes, hypertension, stroke, etc. For example, 6% of the global mortality is linked to physical inactivity (World Health Organization, 2010). Hence, the growing impact of mobile health applications as a medium and tool for informing, educating and motivating users to engage in regular physical activity cannot be underestimated (Matthews et al., 2016). To make these health applications more effective in motivating behavior change, designers often equip them with persuasive features such as Goal-Setting, Self-Monitoring, Reward, etc. Moreover, they are equipped with social features such as Cooperation, Competition, Social Learning, etc., in attempt to utilize social influence to motivate behavior change in social contexts. However, prior to deciding to adopt and/or use a fitness application, on the market users often base their evaluation and judgment on the perceived UX attributes of such applications. For example, Fogg et al. (2002) found that users make their credibility judgment of a website mainly based on the design's look, which can impact adoption. Moreover, Lindgaard et al. (2006) found that users make the decision to stay on a website or proceed to another within the first 50 ms. Hence, it becomes pertinent in the health domain to understand the key drivers of users' adoption of persuasive health applications such as fitness applications.

So far, there are limited studies, in the context of the PTAM, that have investigated the UX design determinants of users' intention to use a fitness application on the market and the moderating effect of culture. Most comparative studies (e.g., Drozd et al., 2012) in the existing literature have been focused on the moderating effect of gender and age in the PTAM. Very little attention has been paid to how culture influences the UX design determinants of user's intention to use a persuasive application aimed at changing behavior. The reason why it is important to investigate the moderating effect of culture is that different cultural groups may be motivated to adopt a persuasive health application for different reasons (i.e., by different UX design attributes). For example, culture A may be motivated to adopt the persuasive health application because of its *perceived aesthetics*. On the other hand, culture B may be motivated to adopt the same application because of its *perceived usability*. In these cases, the designer of the persuasive health application would have to prioritize aesthetics (beauty) and usability (ease of use) in the design of the user interface of the application for culture A and culture B, respectively. To bridge the gap in the existing literature, we conducted an empirical study in the health domain to uncover the strongest UX design determinants of the intention to use a persuasive health application using a mobile fitness application prototype as a case study. Secondly, we investigated the moderating effect of culture using Hofstede's (2011) cultural classification (collectivism vs. individualism) as a comparative analysis framework.

Moreover, the idea of *perceived persuasiveness* being a mediating factor in the PTAM has been scarcely investigated. Most prior studies (e.g., Van der Heijden, 2003) have been focused on users' *attitude toward using* the system. Although Lehto et al. (2012) and Drozd et al. (2012) examined and confirmed the direct effect of *perceived persuasiveness* on *intention to use*, they did not investigate its mediating effect in the PTAM. We argue that, in the context of persuasive systems, *perceived persuasiveness* may be an important mediator in the persuasive technology adoption process ranging from the perception of the UX design attributes of a persuasive system to its eventual adoption. We make this argument because people are more likely to accept and use a behavior change support system to motivate their behavior change if they find it persuasive. As a result, in addition to the moderating effect of culture in the PTAM, we set out to investigate the mediating effect of *perceived persuasiveness* in the adoption of a persuasive health application.

The result of our Partial Least Square Path Modeling (PLSPM) (Sanchez, 2013), shows that, regardless of culture, *perceived usefulness* ($\beta_T = 0.62$, $p < 0.001$) and *perceived aesthetics* ($\beta_T = 0.61$, $p < 0.001$) have the strongest overall effect on the *intention to use* a fitness application, with the overall model accounting for over 60% of the variance of *intention to use*. Comparatively, the direct effect of *perceived usefulness* on *intention to use* in the collectivist model ($\beta_T = 0.90$, $p < 0.001$) is significantly stronger than that in the individualist model ($\beta_T = 0.14$, $p < 0.05$). This cultural difference is as a result of *perceived persuasiveness* partially mediating the direct effect of *perceived usefulness* on the *intention to use* the fitness application in the individualist model. Moreover, the overall effect of *perceived credibility* is strong in the collectivist model ($\beta_T = 0.33$, $p < 0.01$) but weak in the individualist model ($\beta_T = 0.12$, $p < 0.01$). In contrast, the overall effect of *perceived usability* is strong in the individualist model ($\beta_T = 0.21$, $p < 0.001$) but non-significant in the collectivist model ($\beta_T = -0.20$, $p =$ n.s). We discuss the implications of our findings in the context of UX design of persuasive health applications for the respective cultures.

BACKGROUND

In this section, we provide a brief overview of the common UX design attributes in the PTAM, *perceived persuasiveness*, and the two main types of culture in Hofstede's (2011) cultural framework.

UX Design Attributes and Perceived Persuasiveness

UX design attributes are considered important in the design and adoption of human-computer-interaction (HCI) systems, such as websites and other persuasive systems. In the TAM, UX design attributes such as *perceived usability* (aka *perceived ease of use*) and *perceived usefulness* have been found to be strong determinants of the acceptance of information systems

(Davis, 1989). In this section, I provide an overview of the widely researched UX design attributes and *perceived persuasiveness*, which we hypothesized as a possible mediating construct in the PTAM.

Perceived Aesthetics

Perceived aesthetics is the visual appeal of an information system as perceived by the user. It encompasses the classic notion of beauty and the expressive ability (creativity and originality) of the designers, which entails their ability to go beyond the de facto design standards (Tractinsky, 2002; Lavie and Tractinsky, 2004). In empirical studies, *perceived aesthetics* is a measure of the extent to which users believes a persuasive system is aesthetically pleasing and appealing.

Perceived Usability

In general, usability refers to the ease of using a system. Thus, in the context of TAM, perceived usability is regarded as *perceived ease of use* prior to the actual use of an information system. It is often directly influenced by *perceived aesthetics* (Oyibo and Vassileva, 2016, 2017b). In empirical studies, *perceived usability* is a measure of the extent to which the user believes using a persuasive system will be easy and free of effort (Davis, 1989).

Perceived Credibility

Perceived credibility refers to the believability of a system. It is composed of two key dimensions: *perceived trustworthiness* of the system and *perceived expertise* of the system designer (Fogg, 2003b). In empirical research, it is a measure of the extent to which the user believes a system is credible (i.e., professionally designed and trustworthy).

Perceived Usefulness

Perceived usefulness refers to the utility, value or benefit a system brings to the users with regard to meeting their goal. In empirical research, *perceived usefulness* is a measure of the extent to which the users believe that a system will help them to achieve a target behavior, e.g., physical activity, health eating, etc.

Perceived Persuasiveness

Perceived persuasiveness refers to the ability of a system to persuade people to adopt it to motivate their behavior change through its UX design. A system that is perceived persuasive can foster or elicit a positive impression toward the system from the target users (Drozd et al., 2012). In empirical persuasive technology research, *perceived persuasiveness* is a measure of a system's convincingness, level of influence and relevance that will make the target users want to adopt the system to change their behavior.

Culture

Culture is defined as the collective programming of the mind, which affects the way of life of a group of people, including their language, food, preferences, beliefs, relationships, etc. Hofstede et al. (2010) categorized culture into two main headings: *individualist* and *collectivist*. Both classifications have been widely adopted in many HCI and persuasive technology studies (Khaled et al., 2006; Oyibo et al., 2018e). Moreover, a large amount of research (Sun, 2001; Kyriakoullis and Zaphiris, 2015; Oyibo et al., 2016; Oyibo and Vassileva, 2019) in HCI and persuasive technology shows that culture plays a significant role in users' perceptions and usage of information systems, such as websites.

Collectivist Culture

Collectivist culture is the type of culture in which people have the tendency to put the "We" before the "I." Thus, people in collectivist cultures tend to give priority to the pursuit of the goals and aspirations of the group they belong over their personal goals and aspirations. The worldview of "We" before "I" tends to influence collectivist users in many contexts such as behavior change. For example, in the physical activity domain, Oyibo et al. (2018e), using the Social Cognitive Theory (SCT) as a theoretical behavioral framework, found that social factors such as *social support* is more likely to influence the physical activity behavior of collectivist users than personal factors.

Individualist Culture

Individualist culture is the type of culture in which people have the tendency to put the "I" before the "We." Thus, people in individualist cultures tend to give priority to the pursuit of their personal goals and aspirations over the goals and aspirations of the group they belong. The worldview of "I" before "We" tends to influence individualist users in the context of behavior change. For example, in the physical activity domain, Oyibo et al. (2018e), using the SCT as a theoretical behavioral framework, found that personal factors such as *self-efficacy* and *self-regulation* are more likely to influence the physical activity behavior of individualist users than social factors.

RELATED WORK

A substantial amount of studies has been conducted to examine the factors that determine the acceptance of a persuasive health system in the context of TAM. We cover a cross-section of those studies that are related to our work.

Wu et al. (2007) conducted an empirical study to examine the factors that determine the adoption of a mobile health system using Taiwanese health professionals as a case study. They found that *perceived usefulness* had the strongest influence on the *intention to use* a mobile health system. In addition, they found that *perceived ease of use* and *perceived compatibility* (with users' *existing values* and *experiences*) had significant influence on *intention to use*. However, the authors did not take the *perceived persuasiveness* of the health system into consideration in their TAM model. Furthermore, Jeon and Park (2015), in an attempt to replicate Wu et al.'s (2007) findings, explored the factors that influence the adoption of mobile health applications for managing obesity. The authors found that *perceived usefulness*, *perceived ease of use* and *perceived compatibility* [just as in Wu et al. (2007)] are the most important determinants of the *intention to use* a mobile health application. Specifically, they found that *perceived usefulness* is the strongest proximal determinant of *intention to use*. However, the authors did not investigate the *perceived persuasiveness* of the health application in their TAM model and/or the moderating effect of culture.

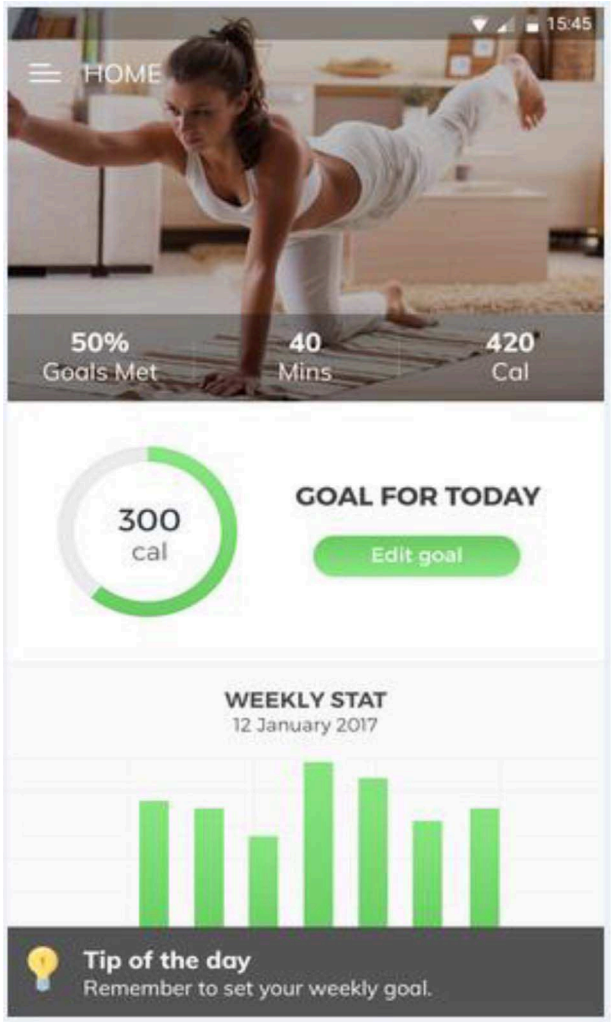

FIGURE 1 | Mobile fitness application design for encouraging home-based exercise behavior[1].

Moreover, the authors used a convenience sample of college students, which may threaten the generalizability of their findings to non-college subjects.

In the same vein, Ketikidis et al. (2011) examined the determinants of the acceptance of health information systems among health professionals. They found that *perceived ease of use*, *relevance* and *subjective norms* are the strongest determinants of the *intention to use* the health information systems. However, the authors did not include the construct, *perceived persuasiveness*, in their TAM model. Dennison et al. (2013) investigated young adults' perspectives on apps aimed at health behavior change using a qualitative approach. The authors found that *accuracy* and *legitimacy*, *security*, *effort required*, and *immediate effects on mood* are among the most important determinants of app usage.

[1]The behavior model in the homepage is taken from https://www.awaken.com/2016/09/home-yoga-practice-questions/.

Moreover, Lehto et al. (2012) investigated the factors that determine the *perceived persuasiveness* of a behavior change support system. They found that *perceived persuasiveness* had a significant effect on users' *intention to use* the system. Finally, Drozd et al. (2012) examined the different factors that influenced the *perceived persuasiveness* of a web-based intervention system and whether *perceived persuasiveness* had the ability to predict users' *intention to use* the system and their *actual use* of the system. They found that *perceived persuasiveness* could predict *intention to use*, which in turn could predict the *actual use* of the system. However, Lehto et al. (2012) and Drozd et al. (2012) did not investigate *perceived usefulness*, which is considered an important determinant of the *intention to use* a persuasive system. In addition, both groups of authors did not investigate how the relationship between *perceived usefulness* and *intention to use* is mediated by *perceived persuasiveness*, neither did they investigate the moderating effect of culture.

Our current study is aimed at bridging the above gaps in the existing literature, especially with regard to the moderating effect of culture, which, to the best of our knowledge, no prior persuasive technology studies in the health domain have investigated. In particular, our study will uncover the PTAM for the collectivist culture on the African continent using Nigeria as a case study. To the best of our knowledge, no study in the health domain has uncovered the PTAM of subjects on the African continent. Formally, our study aims to answer the following research questions:

RQ1. Which of the four commonly known UX design attributes is/are the strongest determinants of the *intention to use* a fitness application?
RQ2. Does the inclusion of *perceived persuasiveness* in the PTAM lead to a better model?
RQ3. Is the effect of *perceived usefulness* on *intention to use* mediated by *perceived persuasiveness*?
RQ4. Are the interrelationships among the UX design attributes, *perceived persuasiveness* and *intention to use* moderated by culture?

METHOD

To answer the research questions, we based our study on the evaluation of a fitness application prototype (which we called "HOMEX") and on users' perceptions. The mobile application is aimed at encouraging regular exercise at home, thus the name "HOMEX." In an online survey, we presented to the study participants a screenshot of the fitness application homepage shown in **Figure 1**. Thereafter, we requested them to answer questions on the four UX design attributes (*perceived aesthetics*, *perceived usability*, *perceived credibility* and *perceived usefulness*), *perceived persuasiveness* and *intention to use*.

Research Model and Hypotheses

In the light of the research questions, using PLSPM (Sanchez, 2013), we formulated a number of hypotheses based on the

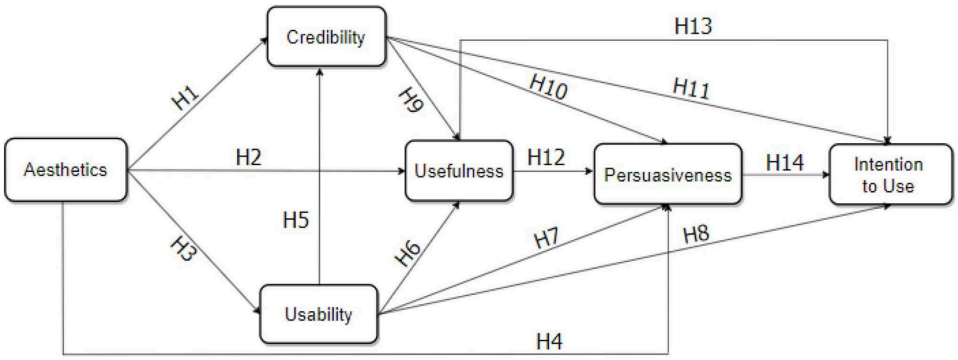

FIGURE 2 | Hypothesized model of persuasive technology acceptance.

existing literature on the extended TAM (Van der Heijden, 2003; Drozd et al., 2012; Lehto et al., 2012). All of the hypotheses (14 in number) are depicted in the research model shown in **Figure 2**. Each of the hypotheses is a positive relationship. For example, H1 means the higher the study participants perceive the fitness application (**Figure 1**) to be aesthetic, the higher they will perceive it to be credible.

Hypotheses With Perceived Aesthetics as an Antecedent (H1-H4)

In persuasive technology, *perceived aesthetics* is considered an important factor in the persuasion process, which has the potential to lead to the adoption of a proposed information system among its target users (Fogg, 2003a; Oinas-Kukkonen and Harjumaa, 2009). Prior research has found that the more aesthetic (i.e., attractive and beautiful) a persuasive system (e.g., a website) is, the more likely uses are to perceive it as usable, credible, useful and persuasive. For example, in a study of the determinants of the *perceived credibility* of a mobile website in the tourism domain, Oyibo and Vassileva (2016, 2017a) found that, regardless of culture and gender, the higher potential users perceived the mobile website design to be aesthetic, the higher they perceived it as credible. Hence, in the current study, we hypothesize that the higher the study participants perceive the fitness application to be aesthetic, the more likely they will perceive it as credible (H1). Similarly, in a study of the TAM for a Dutch generic web portal, Van der Heijden (2003) found that the higher the actual users of the portal perceived it as attractive, the higher they perceived it easy to use and useful. Therefore, in the current study, we hypothesize that the higher the potential users of a fitness application perceive it to be aesthetic, the higher they will perceive it as useful (H2) and usable (H3). Finally, in a study of a health application modeling bodyweight exercise behavior, Oyibo et al. (2018d) found that the higher potential users perceived it to be classically and expressively aesthetic, the higher they viewed the app as persuasive. As a result, in the present study, we hypothesize that the higher the study participants perceived the fitness application prototype to be aesthetic, the higher they will perceive it as a persuasive (H4).

Hypotheses With Perceived Usability as an Antecedent (H5-H8)

In the traditional TAM, *perceived usability* (aka *perceived ease of use*) is considered as one of the two most important determinants of the acceptance of an information system (Davis, 1989). *Perceived usability* is closely linked to the concept of *perceived self-efficacy*, which is the belief in one's ability to perform a given behavior. In behavioral theories such as SCT (Bandura, 1998; Oyibo et al., 2018a), *perceived self-efficacy* has been found to be one of the strongest determinants of health behavior such as physical activity. Correspondingly, in the TAM, *perceived usability*, which entails the perceived level of difficulty and effort in understanding and interacting with a system, has been found to be a strong determinant of the usage of an information system. Apart from system usage, *perceived usability* is associated with UX design attributes such as *perceived credibility, perceived usefulness* and *perceived persuasiveness*. Oyibo and Vassileva (2016, 2017a) found that the higher users perceived a mobile website to be usable, the higher they perceived it as credible. Moreover, Van der Heijden (2003) found that the higher users perceived a generic web portal to be usable, the higher they perceived it to be useful and the higher was their intention to use it. Finally, Oinas-Kukkonen and Harjumaa (2009) postulated that a persuasive system that is easy to use is more likely to persuade users than a persuasive system that is difficult to use. Therefore, in the current study, we hypothesize that the higher the the study participants perceive a fitness application to be usable, the higher they will perceive it as credible (H5), useful (H6), persuasive (H7) and have a positive intention to use it (H8).

Hypotheses With Perceived Credibility as an Antecedent (H9-H11)

In the extended TAM, *perceived credibility* has been found to be an important factor in the information technology adoption process. Marton and Wei Choo (2012) found that the *perceived credibility* of health information sought on the web significantly (positively) influenced its *perceived usefulness* and *attitude toward use*. Moreover, Amin (2007) and Luarn and Lin (2005) found that the higher users perceived a banking system to be credible, the

TABLE 1 | Empirical scales employed in measuring the TAM-based UX design constructs.

Construct	Items in scale
Perceived aesthetics Oyibo et al. (2018b)	*Classic Aesthetics* (low-order construct) 1. The app is visual. 2. The app is clean. 3. The app is pleasant. *Expressive Aesthetics* (low-order construct) 1. The app is fascinating. 2. The app is sophisticated. 3. The app is creative.
Perceived usability Oyibo et al. (2017)	1. The app is easy to use. 2. The app is convenient to use. 3. The app has a clear design. 4. The app has easy orientation.
Perceived credibility Oyibo et al. (2018b)	The app is credible.
Perceived usefulness Davis (1989)	1. The app will help me improve my exercise performance. 2. The app will help me accomplish my exercise goals easily. 3. The app will be useful in my exercise. 4. The app will make it easier to reach my exercise goals.
Perceived persuasiveness Oyibo et al. (2018c)	1. The app would influence me. 2. The app would be convincing. 3. The app would be personally relevant for me. 4. The app would make me reconsider my physical activity habits.
Intention to use Mtebe and Raisamo (2014)	Assuming the app was deployed in real life, I predict that I will use it if I have the opportunity.

higher became their intention to use the system. Based on these findings, in the current study, we hypothesize that the higher potential users perceive a fitness application to be persuasive, the higher they will find it useful (H9), persuasive (H10) and have a positive intention to use it (H11).

Hypothesis With Perceived Usefulness as an Antecedent (H12-H13)

In the traditional TAM, *perceived usefulness,* is considered the most important determinant of the *intention to use* an information system (Davis, 1989). It is regarded as a cognition-based extrinsic motivator, which can be likened to the outcome-expectation construct in behavioral theories such as the SCT (Bandura, 1998). In persuasive systems design, Oinas-Kukkonen and Harjumaa (2009) postulated that a persuasive system that is considered useful is more likely to persuade potential users than a system that is considered otherwise. Moreover, Van der Heijden (2003) found that the higher the actual users of a generic web portal perceived it to be useful, the higher became their intention to use it. Thus, in the current study, we hypothesize that the higher potential users perceive a fitness application to be useful, the higher they will find it persuasive (H12) and have a positive intention to use it (H13).

Hypothesis With Perceived Persuasiveness as an Antecedent (H14)

In the extended TAM, Lehto et al. (2012) and Drozd et al. (2012) found that the higher users perceived behavior change support systems in the health domain to be persuasive, the higher became their *intention to use* such systems. Based on this finding, in the current study, we hypothesize that the *perceived persuasiveness* of a fitness application will positively influence the study participants' *intention to use* it if deployed in a real-life setting (H14).

Exploratory Analysis

Due to the paucity of cross-cultural studies in the current research topic, we adopted an exploratory approach to investigate how the two cultures differ. Similarly, we used an exploratory approach to determine whether including *perceived persuasiveness* in the TAM will lead to a better model and the moderating effect of culture. We are particualrly interested in answering the second research question because, with regard to *attitude* toward (using) a system, there has been a debate whether it shoud be retained or removed from the TAM model. Some researchers have argued that, to achieve a parsimonous model, *attitude* should be excluded from the TAM. Yet, other researchers have provided empirical evidence that supports the need to retain it in the TAM (Van der Heijden, 2003). In the same vein, with regard to *perceived persuasiveness*, we argue that, whether it should be part of the PTAM or not may depend on the target population under investigation and perhaps the domain of interest. As a result, we decided to investigate this postulate in the fitness domain using the two common types of culture as a case study.

Measurement Instruments

Table 1 shows all constructs and the existing studies from which they were drawn. Each item in each of the six constructs was adapted from the original instruments to align it with the context of our study. All of the items were based on a 7-point Likert scale ranging from "*Strongly Disagree – 1*" to "*Strongly Agree – 7*." In particular, *perceived aesthetics* comprises two low-order constructs: *classical aesthetics* and *expressive aesthetics*. Both of these lower-order constructs are regarded as first-order constructs in the PLSPM, both of which combine and serve as indicators to measure *perceived aesthetics*, which is known as a second-order construct (Hair et al., 2014).

Participants

Our study was conducted online. Prior to conducting the study, it was submitted to the Behavioral Research Ethics Board of our university for approval. After approval, we recruited participants who were residents in Canada and United States on Amazon Mechanical Turk (AMT). In addition, we recruited participants who were resident in Nigeria via email. The reason we recruited the Nigerian participants via email is that not many Nigerians were present on AMT, compared with Canadians and Americans. To appreciate participants for their time, they were compensated with US $1.50 for their time. Similarly, the participants recruited from Nigeria via email were compensated with a phone credit

TABLE 2 | Demographics of participants.

Criterion	Subgroup	Number (#)		Percent (%)	
		COL	IND	COL	IND
Gender	Female	29	82	43.3	43.4
	Male	35	106	52.2	56.1
	Other	3	1	4.5	0.5
Age	18–24	26	29	38.8	15.3
	25–34	29	100	43.3	52.9
	35–44	9	39	13.4	20.6
	45–54	–	15	–	7.9
	54+	–	6	–	3.2
	Unspecified	3	–	4.5	–
Education	Technical/Trade School	1	37	1.5	19.6
	High School	2	34	3.0	18.0
	Bachelor	51	86	76.1	45.5
	Masters	10	26	14.9	13.8
	Doctorate	–	4	–	2.1
	Others	3	2	4.5	1.1
Country of origin	Canada	–	89	–	47.1
	United States	–	100	–	52.9
	Nigeria	67	–	100.0	–
Occupation	Employee	34	110	50.7	58.2
	Employer	5	7	7.5	3.7
	Self-employed	6	38	9.0	20.1
	Student	14	26	20.9	13.8
	Other	8	8	11.9	4.2
Years on the internet	1–5	9	1	13.4	0.5
	6–10	30	28	44.8	14.8
	11–15	18	39	26.9	20.6
	16–20	7	66	10.4	34.9
	20+	–	55	–	29.1
	Unspecified	3	–	4.5	–

COL, Collectivist culture; IND, Individualist culture.

card that cost N200 in Nigerian currency. **Table 2** shows the demographics of the valid participants after data cleaning. The individualist group comprises 189 participants, while the collectivist group comprises 67 participants. Though the sample size of the individualist group is larger, both groups meet the minimum sample-size requirement for the building and analysis of a PLS model. The 10-times rule states that "*the sample size should be >10 times the maximum number of inner or outer model links pointing at any latent variable in the model*" (Ned and Pierre, 2018, p. 2). In our PLSPM, a maximum of four items measured a given construct in the research model as shown in **Table 1**. Similarly, a maximum of four exogenous constructs influence an endogenous construct as shown in the research model in **Figure 2**.

RESULTS

This section covers our path analysis, which was carried out using the "plspm" library in R (Sanchez, 2013). Specifically, we present the assessment of the measurement model (aka outer model) and the analysis of the structural model (aka inner model).

Evaluation of the Measurement Models

Prior to analyzing the structural model, it is required that the measurement model be assessed for certain preconditions, including indicator reliability, internal consistency reliability, convergent validity and discriminant validity.

Indicator Reliability: Indicator reliability refers to the degree to which an item, which measures a construct, is reliable (Raines-Eudy, 2000). This criterion for each construct in the measurement models was measured using the outer loading metric, which was >0.7 for each indicator (Hair et al., 2012; see **Table A1**).

Internal Consistency Reliability: Internal consistency reliability refers to the degree to which a set of indicators that purport to measure a particular construct produces similar scores [36]. This criterion for each construct in the measurement models was evaluated using the composite reliability metric known as Dillon-Goldstein's rho (ρ), which was >0.7 for each construct (Hair et al., 2014; see **Table A2**).

Convergent Validity: Convergent validity refers to the degree to which the indicators that measure a particular construct are related to one another. This criterion was measured using the Average Variance Extracted (AVE) metric, which was >0.5 for each construct in the measurement models (Hair et al., 2014; see **Table A3**).

Discriminant Validity: Discriminant validity refers to the degree to which the indicators that measure a particular construct are unrelated to the other constructs in the measurement model. This criterion was measured using the crossloading metric. In each of the measurement models, our result showed that no construct's indicator loaded higher on some other construct than the one it was designed to measure (Hair et al., 2014; see **Tables A4–A6**).

Analysis of Structural Models

In this section, we present the global model and the culture-specific models, in which we examine the goodness of fit (GOF) of each model, coefficient of determination (R^2) of each construct and the path coefficient (β) of each relationship (Sanchez, 2013; Hair et al., 2014). The GOF represents how well a model fits its data. The R^2 value represents the percentage of variance in an endogenous construct explained by the exogenous constructs terminating in the former. Finally, the β value represents the strength of the relationship that exists between two constructs in the model. In addition, we present the total effect (β_T), mediation and multigroup analyses. The total effect captures the overall effect of a particular construct on the target construct. It is calculated by summing the direct and indirect effects. The mediation analysis shows whether a particular construct mediates the relationship between an exogenous construct and an endogenous construct. Finally, the multigroup analysis shows how two models (in our case, the culture-specific models) differ through the comparison of the corresponding relationships in both models.

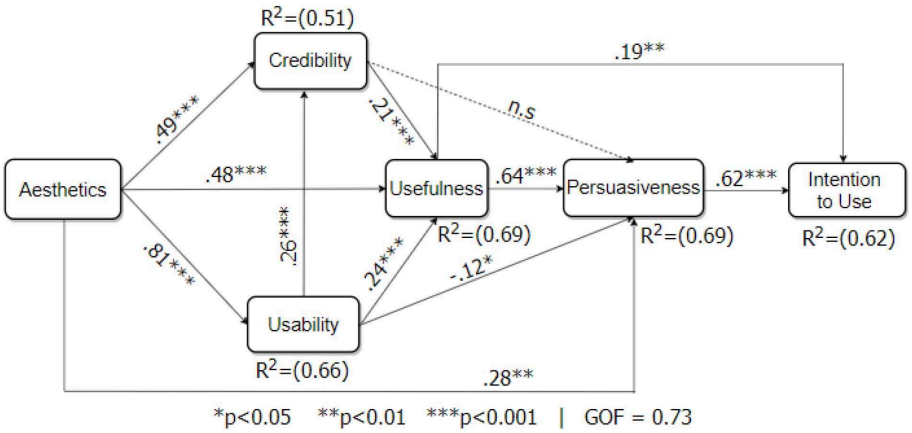

FIGURE 3 | Global persuasive technology acceptance model (for brevity, we have omitted the representation of the non-significant relationships between credibility/usability and intention to use).

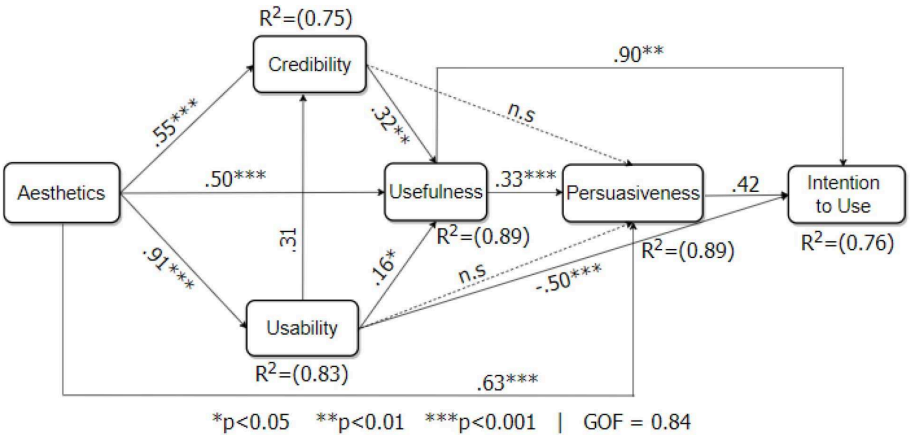

FIGURE 4 | Collectivist persuasive technology acceptance model (for brevity, we have omitted the representation of the non-significant relationships between credibility and intention to use).

Analysis of the Global Model

Figure 3 shows the global model, which is built using the overall population sample of 256 participants. The GOF for the model is 73%, which is considered a good value within the PLSPM community (Sanchez, 2013). The R^2 value for *perceived persuasiveness* and *perceived usefulness* turn out to be the highest (69%) in the model. R^2 values above 60% are considered high values; those between 60 and 30% are considered moderate; and those <30% are considered low (Sanchez, 2013). *Perceived usability* (66%) and *intention to use* (62%) also have a high R^2 value. Specifically, *perceived persuasiveness* together with *perceived usefulness* accounts for the 62% variance of *intention to use*. Moreover, ten of the hypothesized relationships are statistically significant in the global model. In particular, the relationship between *perceived aesthetics* and *perceived usability* ($\beta = 0.81$, $p < 0.001$) is the strongest in the model. The second strongest significant relationship is that between *perceived persuasiveness* and *intention to use* ($\beta = 0.62$, $p < 0.001$). On the other hand, the weakest significant relationship is between *perceived usability* and *perceived persuasiveness* ($\beta = -0.12$, $p < 0.05$), followed by the relationship between *perceived usefulness* and *intention to use* ($\beta = 0.19$, $p < 0.01$). The negative relationship between *perceived usability* and *perceived persuasiveness* (which is counter-intuitive and inconsistent) is explained in the discussion.

Analysis of the Collectivist Model

Figure 4 shows the collectivist model built using the collectivist sample of 67 participants. Most of the parameters in the model are higher than their counterparts in the global model, which is an indication of the moderating effect of culture. For example, the GOF for the collectivist model is 84% (compared with 73% for the global model). The R^2 value for *perceived persuasiveness* is 89% (the highest in the collectivist model, compared with 69% for the global model). Regarding the relationships, ten of the fourteen hypotheses are significant. Just like in the global model, the

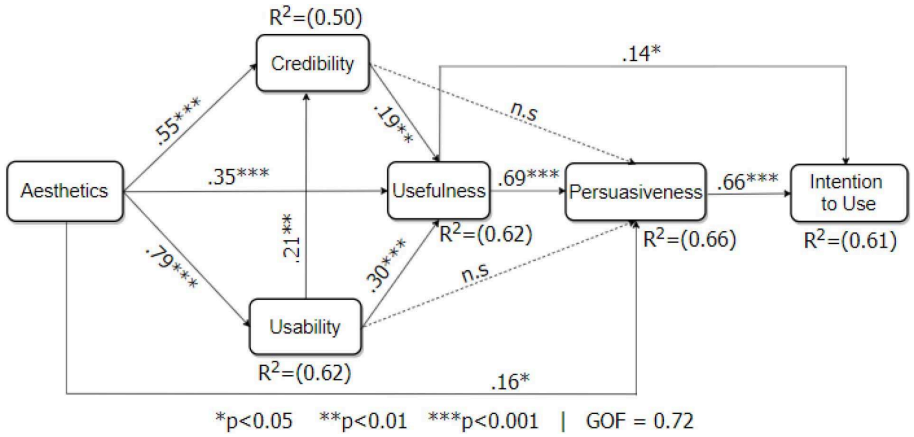

FIGURE 5 | Individualist persuasive technology acceptance model (for brevity, we have omitted the representation of the non-significant relationships between credibility/usability and intention to use).

relationship between *perceived aesthetics* and *perceived usability* ($\beta = 0.91$, $p < 0.001$) is the strongest. The second strongest relationship, which is approximately equal to the strongest, is that between *perceived usefulness* and *perceived intention to use* ($\beta = 0.90$, $p < 0.001$). Specifically, we find a strong negative relationship between *perceived usability* and *intention to use* ($\beta = -0.51$, $p < 0.001$) in the collectivist model. Finally, the weakest of the significant relationships is between *perceived usability* and *perceived usefulness* ($\beta = 0.16$, $p < 0.05$).

Analysis of the Individualist Model

Figure 5 shows the individualist model, which is built using the individualist sample of 189 participants. The GOF for the model is 72%, which is an acceptable (good) value, just as the GOF values of the global and collectivist models (Sanchez, 2013). Regarding the R^2 parameters, *perceived persuasiveness* has the highest value (93%), with *perceived usefulness* ($\beta = 0.69$, $p < 0.001$) and *perceived aesthetics* ($\beta = 0.16$, $p < 0.05$) accounting for its variance. *Perceived usefulness* (62%) and *perceived usability* (62%) are in the second place, while *intention to use* (61%) is in the third place. Specifically, *perceived persuasiveness* ($\beta = 0.66$, $p < 0.001$) and *perceived usefulness* ($\beta = 0.14$, $p < 0.05$) account for the 61% variance of *intention to use*. Finally, just as in the global and collectivist models, the relationship between *perceived aesthetics* and *perceived usability* ($\beta = 0.79$, $p < 0.001$) is the strongest.

Total Effect Analysis

To answer our first research question, we present the total effect of the perceived UX design constructs on *intention to use* as shown in **Figure 6**. In the global model, *perceived persuasiveness* ($\beta_T = 0.62$, $p < 0.001$) has the strongest total effect on *intention to use*, followed by *perceived usefulness* ($\beta_T = 0.62$, $p < 0.001$) and *perceived aesthetics* ($\beta_T = 0.61$, $p < 0.001$). However, *perceived credibility* ($\beta_T = 0.13$, $p < 0.05$) has a weak total effect on *intention to use*, while *perceived usability* ($\beta_T = 0.11$, $p =$ n.s) has no significant total effect. In the collectivist model, *perceived usefulness* ($\beta_T = 1.04$, $p < 0.001$) has the strongest total effect on *intention to use*, followed by *perceived aesthetics* ($\beta_T = 0.77$, $p < 0.001$) and *perceived persuasiveness* ($\beta_T = 0.42$, $p = 0.06$), which is marginally significant. Moreover, *perceived credibility* ($\beta_T = 0.33$, $p < 0.05$) has a strong total effect on *intention to use*, while *perceived usability* ($\beta_T = -0.20$, $p =$ n.s) has no significant total effect. Finally, the total effect profile for the individualist model is similar to that of the global model, with respect to the three strongest determinants, which include *perceived persuasiveness* ($\beta_T = 0.66$, $p < 0.001$) *perceived usefulness* ($\beta_T = 0.60$, $p < 0.001$) and *perceived aesthetics* ($\beta_T = 0.55$, $p < 0.001$). The fourth strongest determinant is *perceived usability* ($\beta_T = 0.21$, $p < 0.001$). *Perceived credibility* ($\beta_T = 0.12$, $p < 0.01$) turns out to have the weakest total effect on *intention to use* in the individualist model.

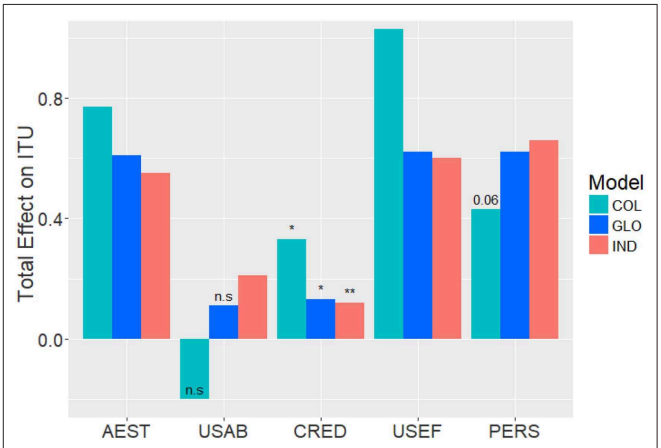

FIGURE 6 | Total Effect of perceived UX design constructs on intention to use (each construct without a label is significant at $p < 0.001$). AEST, Perceived Aesthetics; USAB, Perceived Usability; CRED, Perceived Credibility; USEF, Perceived Usefulness; PERS, Perceived Persuasiveness. ITU, Intention to Use; $^*p < 0.05$; $^{**}p < 0.01$; n.s, non-significant.

TABLE 3 | Coefficient of determination of intention to use with and without perceived persuasiveness in the persuasive technology acceptance model.

	Perceived Persuasiveness Included						Perceived Persuasiveness Excluded					
	R^2			R^2_{Adj}			R^2			R^2_{Adj}		
	GLO	COL	IND	GLO	COL	IND	GLO	COL	IND	GLO	COL	IND
ITU	0.62	0.76	0.61	0.61	0.74	0.60	0.51	0.74	0.47	0.50	0.72	0.46
PERS	0.69	0.89	0.66	0.68	0.88	0.66	–	–	–	–	–	–
USEF	0.70	0.89	0.62	0.69	0.88	0.61	0.70	0.90	0.62	0.90	0.89	0.69
CRED	0.51	0.75	0.50	0.50	0.73	0.50	0.50	0.76	0.49	0.49	0.74	0.48
USAB	0.65	0.83	0.62	0.64	0.82	0.49	0.66	0.82	0.62	0.65	0.80	0.61

GLO, Global population; COL, Collectivist Culture; IND, Individualist Culture; AEST, Perceived Aesthetics; USAB, Perceived Usability; CRED, Perceived Credibility; USEF, Perceived Usefulness; PERS, Perceived Persuasiveness; ITU, Intention to Use.

Adjusted R-Squared Analysis

To answer our second research question, in addition to the prior models, we built the global and culture-specific models with *perceived persuasiveness* excluded from the model. **Table 3** shows the R^2 values for both versions of models. The first version is based on *perceived persuasiveness* included in the model and the second version is based on *perceived persuasiveness* excluded from the model. In the global and individualist models, the R^2 values of intention to use increase by over 10% when *perceived persuasiveness* is included in the model. For the global model, the R^2 value of *intention to use* increases from 51 to 62% (difference−11%); and, for the individualist model, it increases from 47 to 61% (difference−14%). However, for the collectivist model, the R^2 value of *intention to use* decreases from 76 to 74% (difference−2%). These findings indicate that at the global and individualist levels, *perceived persuasiveness* is important to be part of the PTAM. However, at the collectivist level, *perceived persuasiveness* could be excluded from the model to make it more parsimonious. To confirm these finds we computed the adjusted R-squared (R^2-adjust) metric. The R^2-adjust value is a metric that determines whether the inclusion of a predictor in a model improves it beyond what is expected by chance. We see that the R^2-adjust of *intention to use* for the global model and individualist model increases substantially. That of the global model increases from 50 to 61%; that of the individualist model increases from 46 to 60%; however, that of the collectivist model only increases a little (from 72 to 74%).

Mediation Analysis

To answer our third research question, we carried out a mediation analysis to investigate whether *perceived persuasiveness* mediates the relationship between *perceived usefulness* and *intention to use*. In the global model, when *perceived persuasiveness* is excluded from the model, the direct effect of *perceived usefulness* on *intention to use* increases from ($\beta = 0.19$, $p < 0.01$) to ($\beta = 0.63$, $p < 0.001$). The Variance Accounted For (VAF) by the indirect path (*usefulness* → *persuasiveness* → *intention to use*) is 0.39. The VAF is the ratio of the indirect effect to the total effect (which is a sum of the direct and indirect effect of one construct on another) (Hair et al., 2014). The VAF value of 0.39 indicates that *perceived persuasiveness* is a partial mediator of the direct effect of *perceived usefulness* on *intention to use* in the global model. In the collectivist model, when *perceived persuasiveness* is excluded from the model, the direct effect of *perceived usefulness* on *intention to use* is increases from ($\beta = 0.90$, $p < 0.001$) to ($\beta = 0.96$, $p < 0.001$). Despite that the relationship between *perceived persuasiveness* and *intention to use* is not statistically significant at $p < 0.05$ (a requirement for computing VAF), we computed the VAF all the same. The VAF value turned out to be 0.12 (<0.20), confirming that *perceived persuasiveness* does not mediate the direct effect of *perceived usefulness* on *intention to use*. Finally, in the individualist model, when *perceived persuasiveness* is excluded from the model, the direct effect of *perceived usefulness* on *intention to use* increases from ($\beta = 0.14$, $p < 0.05$) to ($\beta = 0.62$, $p < 0.001$). The Variance Accounted For (VAF) by the indirect path (*usefulness* → *persuasiveness* → *intention to use*) is 0.40, indicating that *perceived persuasiveness* acts as partial mediator of the direct effect of *perceived usefulness* on *intention to use* in the individualist model.

Multigroup Analysis

To answer our fourth research question on how the two cultures differ, we conducted a multigroup analysis based on culture (Sanchez, 2013; Hair et al., 2014). The result shown in **Table 4** reveals that both cultures significantly differ in three relationships. First, regarding the relationship between *perceived aesthetics* and *perceived usability*, the two cultures significantly differ ($p < 0.05$), with the relationship being stronger for the collectivist culture ($\beta = 0.91$, $p < 0.001$) than the individualist culture ($\beta = 0.79$, $p < 0.001$). Secondly, the relationship between *perceived usability* and *intention to use* is significantly stronger ($p < 0.01$) for the collectivist culture ($\beta = -0.50$, $p < 0.001$) than the individualist culture ($\beta = 0.01$, $p =$ n.s). Finally, the relationship between *perceived usefulness* and *intention to use* is significantly stronger ($p < 0.01$) for the collectivist culture ($\beta = 0.90$, $p < 0.001$) than the individualist culture ($\beta = 0.14$, $p < 0.05$).

DISCUSSION

We have presented a model of the acceptance of a persuasive health application and the moderating effect of culture using a fitness application prototype as a case study. Overall, 8 or 10 of the 14 hypotheses we formulated were validated in each of the

TABLE 4 | Multigroup analysis showing how collectivist and individualist cultures significantly differ.

Relationship	GLO	COL	IND	*p*-value	Sig.
AEST → USAB	0.81***	0.91***	0.79***	0.0200	Yes
AEST → CRED	0.49***	0.55***	0.55***	0.2305	No
AEST → USEF	0.48***	0.50***	0.35***	0.1865	No
AEST → PERS	0.28***	0.63***	0.16*	0.1296	No
AEST → ITU	0.05 n.s	−0.05 n.s	−0.02 n.s	0.328	No
USAB → CRED	0.26***	0.31	0.21**	0.4105	No
USAB → USEF	0.24***	0.16*	0.30***	0.3821	No
USAB → PERS	−0.12*	0.01 n.s	−0.16 n.s	0.2813	No
USAB → ITU	−0.11 n.s	−0.50***	0.01 n.s	0.0026	Yes
CRED → USEF	0.21***	0.32**	0.19**	0.4341	No
CRED → PERS	0.07 n.s	0.03 n.s	0.11 n.s	0.2612	No
CRED → ITU	0.03 n.s	0.06 n.s	−0.04 n.s	0.3054	No
USEF → PERS	0.64	0.33***	0.69***	0.2137	No
USEF → ITU	0.19*	0.90***	0.14*	0.0013	Yes
PERS → ITU	0.62***	0.42	0.66***	0.1533	No

*GLO, Global population; COL, Collectivist Culture; IND, Individualist Culture; AEST, Perceived Aesthetics; USAB, Perceived Usability; CRED, Perceived Credibility; USEF, Perceived Usefulness; PERS, Perceived Persuasiveness; ITU, Intention to Use; n.s, non-significant; *p < 0.05; **p < 0.01; ***p < 0.001.*

three models. In the following sections we discuss the hypotheses in the light of the results obtained, the cultural difference and the overall effect of the UX design constructs on the *intention to use* in the context of our research questions.

Validation of Hypotheses

Table 5 provides a summary of the validated and non-validated hypotheses. Overall, 10 out of the 14 hypotheses are validated in the global and individualist models, but only 8 of them are validated in the collectivist model. We discuss each of the validated hypotheses and the moderating effect of culture.

Validation of Perceived Aesthetics Related Hypotheses (H1-H4)

The summarized findings in **Table 5** shows that, regardless of culture, all four of the aesthetics-related hypotheses (H1-H4) are supported, except that, in the individualist model, the relationship between *perceived aesthetics* and *perceived persuasiveness* (H4) is relatively weak ($\beta = 0.16$, $p < 0.05$). That said, the significant direct effect of *perceived aesthetics* on every other construct in the model (except *intention to use*) indicates how influential *perceived aesthetics* is in the PTAM. Specifically, the validation of the first four hypotheses shows that the higher users perceive the *visual aesthetics* of a persuasive health application, the higher they will perceive the other UX attributes such as *perceived usability*, *perceived credibility* and *perceived usefulness*. In addition, the higher they will perceive the application to be *persuasive*. Particularly, *perceived aesthetics* tends to have a higher direct effect on the proximal constructs (e.g., *perceived usability*) than the distal constructs (e.g., *perceived persuasiveness*), especially in the global and individualist models. For example, in the global model, the influence of *perceived aesthetics* on *perceived usability* is ($\beta = 0.81$, $p < 0.001$) and that on *perceived persuasiveness* is ($\beta = 0.28$, $p < 0.01$). Similarly, in the individualist model, the corresponding direct effects are ($\beta = 0.79$, $p < 0.001$) and ($\beta = 0.16$, $p < 0.05$), respectively. The multigroup analysis shows that the influence of *perceived aesthetics* on *perceived usability* is significantly stronger in the collectivist culture ($\beta = 0.91$, $p < 0.001$) than in the individualist culture ($\beta = 0.79$, $p < 0.001$). This finding is consistent with an earlier finding in tourism-based mobile websites. In that study (Oyibo and Vassileva, 2016), the authors found that, regardless of the mobile website design (e.g., color scheme, layout, etc.), the relationship between *perceived aesthetics* and *perceived usability* is significantly stronger for the collectivist culture than for the individualist culture ($p < 0.05$). The relationship between *perceived aesthetics* and *perceived usability* is often regarded as a "halo effect," which is a psychological cognitive bias that causes the perception of one attribute of an object to affect the perception of another attribute (Soper, 2014; Oyibo and Vassileva, 2017a). The current finding in the fitness domain confirms the prior finding in the tourism domain that the aesthetic-usability "halo effect" is significantly stronger in the collectivist culture than in individualist culture.

Validation of Perceived Usability Related Hypotheses (H5-H8)

Table 5 shows that, at least, one or two of the usability-related hypotheses (H5-H8), in which *perceived usability* is an antecedent, are validated in each of the three models. In the global and individualist models, the hypothesized relationships between *perceived usability*, on one hand, and *perceived credibility (*H5) and *perceived usefulness* (H6), on the other hand, are supported by the data. This suggests that the higher individualist users perceive the *usability* of a persuasive health application, the higher they perceive it to be *credible* and *useful*. For the collectivist culture, the relationship between *perceived usability* and *perceived credibility* is not significant ($\beta = 0.31$, p = n.s), while that between *perceived usability* and *perceived usefulness* is relatively weak ($\beta = 0.16$, $p < 0.05$). However, the multigroup analysis showed no significant difference between both cultures with respect to both relationships. Moreover, in the global model, the relationship between *perceived usability* and *perceived persuasiveness* is negative and weak ($\beta = -0.12$, $p < 0.05$), which invalidates our hypothesis (H7). Moreover, regarding H8, the relationship between *perceived usability* and *intention to use* ($\beta = -0.51$, $p < 0.001$) in the collectivist model is negative, which does not support our hypothesis. It is noteworthy that the negative path coefficient between both constructs is as a result of an inconsistent mediation by *perceived usefulness* and/or *perceived persuasiveness*, which tend to serve as suppressors (Hair et al., 2014; Kenny, 2018). For example, when *perceived usefulness* is excluded from the model, the direct effect of *perceived usability* on *intention to use* reduces to ($\beta = -0.17$, $p =$ n.s.). Furthermore, when *perceived usefulness* and *perceived persuasiveness* are both excluded from the model, the direct effect of *perceived usability* on *intention to use* changes direction and increases in magnitude ($\beta = 0.54$, $p < 0.001$). These changes in the sign and strength of the relationship between *perceived usability* and *intention to use*

TABLE 5 | Summary of validated and non-validated hypotheses.

No.	Hypothesis	Relationship	GLO	COL	IND
H1	The *perceived aesthetics* of a persuasive health application will positively influence its *perceived credibility*.	AEST → CRED	√	√	√
H2	The *perceived aesthetics* of a persuasive health application will positively influence its *perceived usefulness*.	AEST → USEF	√	√	√
H3	The *perceived aesthetics* of the persuasive health application will positively influence its *perceived usability*.	AEST → USAB	√	√	√
H4	The *perceived aesthetics* of the persuasive health application will positively influence its *perceived persuasiveness*.	AEST → PERS	√	√	√
H5	The *perceived usability* of the persuasive health application will positively influence its *perceived credibility*.	USAB → CRED	√	×	√
H6	The *perceived usability* of a persuasive health application will positively influence its *perceived usefulness*.	USAB → USEF	√	√	√
H7	The *perceived usability* of the persuasive health application will positively influence its *perceived persuasiveness*.	USAB → PERS	-	×	×
H8	The *perceived usability* of a persuasive health application will positively influence users' *intention to use* it.	USAB → ITU	×	-	×
H9	The *perceived credibility* of a persuasive health application will positively influence its *perceived usefulness*.	CRED → USEF	√	√	√
H10	The *perceived credibility* of a persuasive health application will positively influence its *perceived persuasiveness*.	CRED → PERS	×	×	×
H11	The *perceived credibility* of a persuasive health application will positively influence users' *intention to use* it.	CRED → ITU	×	×	×
H12	The *perceived usefulness* of a persuasive health application will positively influence its *perceived persuasiveness*.	USEF → PERS	√	√	√
H13	The *perceived usefulness* of a persuasive health application will positively influence users' *intention to use* it.	USEF → ITU	√	√	√
H14	The *perceived persuasiveness* of a persuasive health application will positively influence users' *intention to use* it.	PERS → ITU	√	×	√

"√" indicates the hypothesis is supported, with the bolded one indicating that the relationship in question is strong ($\beta \geq 0.20$; $p < 0.05$) (Chin, 1998); "×"indicates the hypothesis is not supported; "-" indicates the hypothesis is a negative relationship and thus not supported. GLO, Global population; COL, Collectivist Culture; IND, Individualist Culture; AEST, Perceived Aesthetics; USAB, Perceived Usability; CRED, Perceived Credibility; USEF, Perceived Usefulness; PERS, Perceived Persuasiveness; ITU, Intention to Use.

confirms that *perceived usefulness* and *perceived persuasiveness* are acting as suppressors.

Validation of Perceived Usefulness Related Hypotheses (H12 and H13)

As shown in **Table 5**, the two usefulness-related hypotheses (H12 and H13), in which *perceived usefulness* is an antecedent, are validated in each of the three models. The validation of H12 means that, regardless of culture, the higher a user perceives a persuasive health application to be *useful*, the higher the user will find it *persuasive*. Finding the application *persuasive*, in the context of our study, means, among other things, the application under evaluation makes the user want to reconsider his/her physical activity habits. Though the relationship between *perceived usefulness* and *perceived persuasiveness* is stronger in the individualist culture ($\beta = 0.69$, $p < 0.001$) than in the collectivist culture ($\beta = 0.33$, $p < 0.01$), the result of the multigroup analysis shows that there is no significant difference ($p > 0.05$) between both path coefficients. Moreover, the validation of H13 means that, regardless of culture, the higher a user perceives a persuasive health application to be *useful*, the higher the user's *intention to use* the application becomes. The result of the multigroup analysis shows that the influence of *perceived usefulness* on the *intention to use* the application is significantly stronger ($p < 0.01$) for the collectivist culture ($\beta = 0.90$, $p < 0.001$) than for individualist culture ($\beta = 0.14$, $p < 0.05$). This means that the collectivist group is more likely to adopt a persuasive health application based on its *perceived usefulness* than the individualist group. One plausible explanation for the relatively weak relationship between *perceived usefulness* and *intention to use*, for the individualist culture, is that this direct relationship is partially mediated by *perceived persuasiveness* (VAF = 4.0) as we showed in the Mediation Analysis section. However, this is not the case for the collectivist culture. This finding suggests that members of the collectivist culture are more likely to adopt a persuasive health application based on its *perceived usefulness* than members of the individualist culture. In particular, prior research (Van der Heijden, 2003; Lehto et al., 2012) has demonstrated that users' *intention to use* a persuasive application has the potential to influence the *actual use* of the application.

Validation of Perceived Persuasiveness Related Hypotheses (H14)

The fourteenth hypothesis (H14) is on the relationship between *perceived persuasiveness* an *intention to use*. As shown in **Table 5**, H14 is validated in global model as well as in the individualist model. This suggests that the more individualist users find a health application *persuasive* the more likely they are to adopt it. Unfortunately, in the collectivist model, though the magnitude of the relationship between *perceived persuasiveness* and *intention to use* is relatively high ($\beta = 0.42$, $p = 0.06$), the significance test showed that it is not significant at $p < 0.05$. Thus, given that there is a marginal significance of the relationship between *perceived persuasiveness* and *intention to use*, further studies, especially with a larger sample size, need to be conducted in the future to examine this relationship among the collectivist group. In the meantime, the finding that the relationship between *perceived persuasiveness* and *intention to use* is significant for the individualist culture is consistent with the existing finding in the literature among individualist populations (Van der Heijden, 2003; Drozd et al., 2012). For example, in a study that investigated the factors that determine the use of a Norwegian health-based persuasive system, Drozd et al. (2012) found that the relationship between *perceived persuasiveness* and *intention to use* is strongly significant among the target individualist population. Thus, our current study replicates this finding in the context of fitness application.

TABLE 6 | Determinants of the intention to use profile.

Model	Order of strength of UX design constructs on intention to use
Global	*[Persuasiveness, Usefulness, Aesthetics], [Credibility, Usability]*
Collectivist	*Usefulness, Aesthetics, Persuasiveness*[1], *Credibility, Usability*
Individualist	*Persuasiveness, Usefulness, Aesthetics, Usability, Credibility*

The underlined constructs have a significant total effect on intention to use, with solid and dashed lines representing strong total effects ($\beta_T >= 0.2$, $p < 0.5$) and weak total effects, respectively. The numerical difference between each pair of constructs in brackets is <0.05. The superscripted construct indicates its total effect on intention to use is marginal ($p = 0.06$).

Summary of Main Findings

In this section, we summarize the main findings of this cross-cultural investigation in the light of the research questions it aims to address.

Most Important UX Design Determinants of Intention to Use

The first research question we set to answer states, "*Which of the four commonly known UX design attributes is/are the strongest determinants of the intention to use a persuasive health application*?" **Table 6** answers this question. It shows all of the UX design determinants of *intention to use* in decreasing order of strength.

As shown, overall, without considering culture and *perceived persuasiveness* (which is a consequence of the perceived UX design attributes), *perceived usefulness* and *perceived aesthetics* are the strongest determinants of a users' *intention to use* a persuasive health application such as a fitness application. Furthermore, our path analysis showed that *perceived credibility* (which is in third place in order of strength) is a weak determinant of the *intention to use* a persuasive health application. In particular, our result showed that *perceived usability* (which is in the last position) is a non-determinant of the *intention to use* a persuasive health application. For the collectivist culture, *perceived usefulness* is the strongest determinant of the *intention to use* a persuasive health application, followed by *perceived aesthetics* and *perceived credibility*. *Perceived usability*, just as in the global model, turns out to be a non-determinant of the *intention to use* a persuasive health application for the collectivist culture. Finally, for the individualist culture, the determinants of *intention to use* profile is similar to that of the global population, except that *perceived usability* (which is only significant in the individualist model) and *perceived credibility* switched positions.

In sum, based on the determinants profile in **Table 6**, our findings indicate that *perceived usefulness* (a pragmatic/utilitarian attribute) and *perceived aesthetics* (a hedonic/affective attribute) are the most important UX design determinants of users' *intention to use* a persuasive health application. Pragmatic/utilitarian attributes reflect the practical benefits users will derive from using a health application, while hedonic/affective attributes appeal to the users visually and emotionally. In the field of HCI design, there has been a debate on which of these two types of attribute designers should focus on. For example, Ravindra and Pallavi asked the question, "*Should a design manager invest more in improving aesthetics (hedonic benefit) or function (utilitarian benefit)?*" (p. 11). The answer to this question, in the context of our current findings in the PTAM, is that design managers should invest in improving both functionality (*usefulness*) and beauty (*aesthetics*). However, for the collectivist culture, designers should focus more on *usefulness* than *aesthetics*. On the other hand, for the individualist culture, designers should strike a balance between *usefulness* and *aesthetics*. Aesthetics can be enacted through the appropriate choice of colors, layout of content, use of images, choice of fonts, etc. On the other hand, usefulness can be enacted by equipping the health application with supportive and motivational features that users care about the most. For example, research shows that Goal-Setting/Self-Monitoring (Orji et al., 2018) is a fundamental feature of a persuasive health application users care about. Moreover, research (Oyibo and Vassileva, 2019) shows that Goal-Setting/Self-Monitoring and Reward are some of the most persuasive features users from both types of culture are susceptible to. So highlighting a feature such as Goal-Setting/Self-Monitoring in the advertisement of the application will amount to showcasing one of its utilities to the users (helping them track their behavior), which can help inform users' ultimate decision to use the application.

Importance of Perceived Persuasiveness in the PTAM

Our second research question states that, "*Does the inclusion of perceived persuasiveness in the PTAM lead to a better model*?" The answer to this research question is moderated by culture. For the individualist culture, the answer is "yes." Upon including *perceived persuasiveness* in the individualist model, the adjusted R^2 value increases substantially by 14% (see **Table 3**), indicating a better model compared with the individualist model without *perceived persuasiveness*. However, for the collectivist culture, the answer is "no." Upon including *perceived persuasiveness* in the collectivist model, the adjusted R^2 value decreases by 2%, indicating a worse model compared with the collectivist model without *perceived persuasiveness*. However, overall, the answer to the research question is "yes." Upon including *perceived persuasiveness* in the global model, the adjusted R^2 value increases by 11%, indicating a better model compared with the global model without *perceived persuasiveness*. In sum, overall, *perceived persuasiveness* is important in the PTAM. However, at the cultural level, it is only important for the individualist group. There have been recommendations in the existing literature to have *attitude* toward an information system (in our case, *perceived persuasiveness*) removed from the TAM to realize a parsimonious model. On one hand, some researchers have argued that it is not important to the TAM, making *perceived usefulness* the most proximal, unmediated determinant of the *intention to use* an information system (López-Bonilla and López-Bonilla, 2016). On the other hand, other researchers have found *attitude* useful in the model and recommended that it be kept (Van der Heijden, 2003). In the light of this debate and with regard to *perceived persuasiveness* (our mediating construct of interest), we found and argue that the question of including or excluding it from the PTAM boils down to the target population being modeled. See the next section for more detail on the mediating effect

of *perceived persuasiveness* and its relevance in the culture-specific PTAMs.

Perceived Persuasiveness as a Mediator in the PTAM

Our third research question states, "*Is the effect of perceived usefulness on intention to use mediated by perceived persuasiveness*?" The answer to this research question is "yes" for the individualist culture and "no" for the collectivist culture. As shown in the mediation analysis (see section Mediation Analysis), in the individualist model, the variance accounted for (VAF) by the indirect path (*perceived usefulness* → *perceived persuasiveness* → *intention to use*) is 39%. However, the corresponding metric in the collectivist model is 12%. Given Hair et al.'s (2014) guideline that a VAF value of <20% indicates no mediation, that between 20 and 80% indicates partial mediation, and that above 80% indicates full mediation, we can conclude in the following ways. In the individualist model, *perceived persuasiveness* partially mediates the effect of *perceived usefulness* on the *intention to use* a fitness application. However, in the collectivist model, *perceived persuasiveness* does not mediate the effect of *perceived usefulness* on the *intention to use* a fitness application. These findings suggest that, in the PTAM, the proximal construct, *perceived persuasiveness* (the belief that a persuasive system has the ability to influence one to adopt it to motivate one's behavior change) is more likely to be relevant in the individualist culture than in the collectivist culture. Furthermore, these findings suggest that the individualist culture has a longer path to persuasive systems adoption than the collectivist culture. Specifically, for the individualist culture (see **Figure 5**), the most significant path to the fitness application adoption is *perceived aesthetics* → *perceived usefulness* → *perceived persuasiveness* → *intention to use*. However, for the collectivist culture (see **Figure 4**), the most significant path to the fitness application adoption is *perceived aesthetics* → *perceived usefulness* → *intention to use*. In the context of Elaboration Likelihood Model (Petty et al., 2009), the longer path to persuasion is more likely to lead to an enduring adoption of the target persuasive system. In this regard, the individualist path that involves *perceived persuasiveness* is more likely to result in a lasting persuasive system adoption than the collectivist path that does not involve *perceived persuasiveness*. The implication of the results of the mediation analysis is that the proximal construct (*persuasive persuasiveness*) could be excluded from the collectivist PTAM. However, it is important in the individualist model. The second implication (which follows from the first) is that the individualist culture is more likely to use a persuasive health application for a longer time if its members are eventually persuaded (through the app's usefulness and aesthetics) to adopt the app. That said, more studies need to be conducted in future work to consolidate the findings and test its generalizability to other domains than fitness.

Cultural Differences in the Relationships Between Constructs in the PTAM

Our fourth research question states, "*Are the interrelationships among the UX design attributes, perceived persuasiveness and intention to use moderated by culture*?" The answer to this research question is "yes." Specifically, we found that the relationship between *perceived aesthetics* and *perceived usability* is stronger for the collectivist culture than the individualist culture. This suggests that the collectivist group is more likely to be affected by the aesthetic-usability "halo effect," which is a cognitive bias that causes the perception of one attribute of an object to affect the perception of another attribute (Soper, 2014). This finding (aesthetic-usability relationship), in particular, replicates the extant finding in mobile website design (Oyibo and Vassileva, 2016). Secondly, we found that the relationship between *perceived usability* and *intention to use* is stronger for the collectivist culture than for the individualist culture. However, this relationship, which is negative, is as a result of an inconsistent mediation by *perceived usefulness* and *perceived persuasiveness* of the *perceived usability* on *intention to use*. Therefore, further research needs to be done to investigate this relationship. Thirdly, we found that the relationship between *perceived usefulness* and *intention to use* is stronger for the collectivist culture than for the individualist culture. This finding can be attributed to the finding that *perceived persuasiveness* partially mediates the effect of *perceived usefulness* on *intention to use* for the individualist culture but does not for the collectivist culture. Hence, we see that the direct effect of *perceived usefulness* on the *intention to use* a fitness application is stronger for the collectivist culture than for the individualist culture. Moreover, as shown in **Figure 6**, with respect to total effect of *perceived usefulness* on the *intention to use* a fitness application is stronger for the collectivist culture than for the individualist culture, with the strength of the total effect of the former doubling that of the latter. On a similar note, with respect to total effect of perceived UX design attributes on the *intention to use* a fitness application, as shown in **Figure 6**, we find that *perceived credibility* seems to be more important to the collectivist culture, while *perceived usability* seems to be more important to the individualist culture. Thus, after taking care of *perceived usefulness* and *perceived aesthetics*, for the collectivist culture, designers should focus on *perceived credibility* (professional and trustworthy design) as a third UX design attribute. However, for the individualist culture, designers should focus on *perceived usability* (ease of use of the persuasive system) as a third UX design attribute.

Contributions

Our contributions to research are as follows. Our paper is the first to demonstrate how culture influences the UX design determinants of the adoption of a fitness application in the context of PTAM by comparing two different populations from two different continents. To the best of our knowledge, it is the first to present the PTAM of subjects from a collectivist culture in Africa (Nigeria), which has been widely understudied in PT research (Orji and Moffatt, 2016), and compare it with the PTAM of subjects from an individualist culture (Canada/United States). Moreover, it is the first to demonstrate that, regardless of culture, both hedonic and utilitarian attributes (i.e., *perceived aesthetics* and *perceived usefulness*, respectively) are important UX design determinants and, hence, need to be catered for in the design of fitness apps

aimed at motivating physical activity behavior to increase their adoption. Finally, our paper is the first to demonstrate that, while *perceived persuasiveness* is an important construct in the PTAM for a certain population (Canadians/Americans), it is not for another (Nigerians). Particularly, in the individualist model, we showed that the amount of the variance of the *intention to use* a fitness app accounted for by the path model increases by 14% upon inclusion of *perceived persuasiveness* in the model.

Limitations

Our study has several limitations. The first limitation is that it is based on the perception of the UX design attributes and persuasiveness of a fitness application prototype rather than the usage of an actual application. This limitation may threaten the generalization of our findings to the application domain, in which participants used a real-life application. The second limitation of our study is that the sample sizes for the two cultures are not balanced. The individualist sample had a larger sample size ($n = 189$) than the collectivist culture ($n = 67$). This might have resulted in a higher chance of achieving statistical significance in the individualist model than in the collectivist model as a result of the former having a larger sample size. The third limitation is that, given that the composition of each type of culture is made up of one or two countries (Canada/United States as individualist and Nigeria as collectivist), the generalizability of our findings to all of the countries that fall under each type of culture may be limited. For example, our collectivist-based finding may not generalize to the Chinese-based collectivist culture. The fourth limitation of our study is that we did not consider the effect of other key demographic factors such as education, gender, education, etc., in our PTAM model. A fifth limitation is that we used only one item to measure *perceived credibility* compared with the other constructs in the PLSPM. Though, research (Bergkvist and Rossiter, 2007) has shown that a single-item construct could be as reliable as a multi-item construct, we acknowledge that the decision to use one item to measure *perceived credibility* may not have been the very best. The reason is that *perceived credibility* could have meant different things to different respondents. For this reason, it could have been better to use multiple items to reduce the chances of different interpretations. That said, in future work, we look forward to addressing this and some of the other limitations.

CONCLUSION

In this paper, we presented the persuasive technology acceptance model in the fitness application domain by focusing on the two major types of culture: collectivist (Nigeria) and individualist (Canada/United States). Specifically, we uncovered the strongest UX design determinants of the intention to use a fitness application and the moderating effect of culture. Furthermore, we looked at how *perceived persuasiveness* mediates the effect of *perceived usefulness* on the *intention to use* a fitness application. We found that the strongest UX design determinants of the *intention to use* a fitness application, regardless of culture, is *perceived usefulness* (which is significantly stronger for the collectivist culture than for the individualist culture), followed by *perceived aesthetics*. Comparatively, for the collectivist culture, we found that *perceived credibility* is the third strongest determinant of the *intention of use*, while *perceived usability* is not a significant determinant. However, for the individualist culture, we found that *perceived usability* is the third strongest determinant of the *intention of use*, followed by *perceived credibility* (which has a weak overall effect on *intention to use*). Finally, we found that *perceived persuasiveness* partially mediates the effect of *perceived usefulness* on *intention to use* for the individualist culture but not for the collectivist culture. In summary, our findings underscore the need for designers of persuasive technologies such as fitness applications to focus on both utility and beauty in their UX design. However, for the collectivist culture, designers should focus more on utility (*perceived usefulness*) than beauty (perceived aesthetics). On the other hand, for the individualist culture, designers should strike a balance between utility (*perceived usefulness*) and beauty (*perceived aesthetics*). Both approaches have the tendency of increasing the adoption rate of persuasive health applications in the respective cultures. In future work, we intend to investigate the replication of our findings using an actual fitness application aimed at motivating behavior change in both types of culture.

DATA AVAILABILITY STATEMENT

The datasets for this article are not publicly available because ethics requirements do not allow releasing the data without a new behavior ethics approval.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of Saskatchewan Research Ethics Board. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

KO designed and conducted the study. KO and JV contributed to preparing the manuscript and approved the final version.

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SUPPLEMENTARY MATERIAL

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