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THE USE OF VIRTUAL REALITY TO PROMOTE THE PRACTICE OF PHYSICAL ACTIVITY

TESIS DOCTORAL

Presentada por:

Jessica Navarro Garrido

Dirigida por:

Dra. Rosa Mª Baños Rivera

Dr. Ausiàs Cebolla Martí

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SUMMARY IN SPANISH / RESUMEN EN ESPAÑOL

1. Introducción

La actividad física (AF) puede definirse como cualquier movimiento corporal producido por los músculos esqueléticos que requiere un gasto de energía (Thivel et al., 2018). Cada vez hay más pruebas que respaldan los beneficios para la salud de la AF, por lo que ser físicamente activo es un mensaje común en cualquier campaña de promoción de la salud (Warburton & Bredin, 2016). De igual modo, la práctica de AF está cada vez más vinculada a la mejora del bienestar y la salud mental de los individuos (Lee & Russell, 2003; Stanton et al., 2014).

Con el fin de lograr tales beneficios, la organización mundial de la salud (OMS) propone una serie de recomendaciones a nivel mundial, de acuerdo a la edad de los individuos (OMS, 2010). A pesar de los beneficios que la práctica de AF proporciona en los individuos y del incremento de campañas que se ponen en marcha para promover su práctica, todavía gran parte de la población no cumple con los mínimos recomendados. De hecho, España es el octavo país de la Unión Europea en su conjunto y el quinto país de Europa en el que el mayor porcentaje de la población no cumple las recomendaciones mínimas de la OMS (Mayo, 2017).

Según la OMS (2010), la inactividad física es una pandemia mundial que se ha convertido en una de las principales causas de muerte en el mundo. De hecho, constituye el cuarto factor de riesgo más importante de mortalidad (OMS, 2010). De igual modo, se ha considerado la inactividad física como uno de los principales contribuyentes a los costos de la atención de la salud y a la pérdida de productividad de un país (Kruk, 2014). Es por este motivo, que se considera necesario seguir desarrollando intervenciones dirigidas a promover la práctica de AF entre la población.

La literatura muestra que hay múltiples barreras a superar si se quiere conseguir promover la práctica de AF. Hesketh et al. (2017) concluyen que la AF y el comportamiento sedentario entre los 0 y 6 años estan asociados a sus preferencias personales, su nivel de desarrollo, su salud, el papel que los padres adquieren en este tema así como los hermanos y compañeros más cercanos, el ambiente donde el niño se desarrolla, la seguridad del niño y el

clima de la ciudad donde viven. De todas estas variables, estos autores concluyen, que las barreras y los facilitadores interpersonales (por ejemplo, los padres, los cuidadores y la familia) son las más importantes a tener en cuenta en los niños de estas edades.

Otros autores, como Rees et al. (2006), afirman que en los niños de 11 a 16 años muestran barreras en la misma línea que los resultados encontrados en poblaciones más jóvenes, como las interpersonales (por ejemplo, la escuela, la familia y los amigos) y la existencia de recursos prácticos y materiales como el tiempo y el dinero. Sin embargo, estos autores identifican la relevancia de un tipo de barrera adicional relacionada con el individuo (por ejemplo, la falta de confianza en las propias habilidades, los sentimientos de incomodidad durante la AF, la falta de motivación, la preferencia por otras habilidades, la falta de conocimiento sobre los beneficios de la AF y la autoconciencia sobre el cuerpo y la apariencia física).

En relación con la población adolescente entre 13 y 18 años de edad, Martins et al. (2015) concluyen la existencia de barreras tales como una mala actitud hacia la AF, falta de motivación, falta de disfrute, baja percepción de competencia, preocupaciones acerca de la imagen corporal, percepción de la feminidad y normas sociales incompatibles con la práctica de AF, falta de tiempo, influencias sociales negativas (por ejemplo, de la familia, amigos o maestros), falta de oportunidades relacionadas con el lugar donde viven (por ejemplo, infraestructura, transporte o seguridad) y períodos de vida asociados con los cambios (por ejemplo, el cambio de la escuela primaria a la escuela secundaria o de la escuela secundaria al mundo del trabajo).

En relación a la población adulta, las principales variables que se han considerado como barreras para la práctica de la AF han sido principalmente la falta de motivación, la falta de tiempo (Cerin et al., 2010; Justine et al., 2013; Herazo-Beltran et al., 2017; Hoare et al., 2017), falta de apoyo social en la práctica (Justine et al., 2013; Herazo-Beltrán et al., 2017; Hoare et al., 2017), los problemas de salud, la falta de energía o el miedo a las lesiones (Cerin et al., 2010; Moschny et al., 2011; Herazo-Beltrán et al., 2017; Schoeny et al., 2017), falta de habilidades (Justine et al., 2013; Herazo-Beltran et al., 2017; Hoare et al., 2017), ausencia de disfrute (Hoare

et al., 2017) y falta de recursos (Cerin et al., 2010; Moschny et al., 2011; Justine et al., 2013; Herazo-Beltran et al., 2017; Schoeny et al., 2017). En general, las barreras hacia la AF son comunes a ambos géneros. Sin embargo, hay una barrera que aparece con mayor frecuencia entre la población femenina, la preocupación por la imagen corporal. Las mujeres experimentan una mayor autoconciencia de su apariencia física durante la AF (Robbins et al., 2003). Esta mayor conciencia de sí misma las hace menos propensas a participar en la AF (Slater & Tiggemann, 2011).

En relación con la población con sobrepeso u obesidad, la literatura muestra la existencia de barreras internas para el individuo como el propio sobrepeso (Hulens et al., 2001; Egan et al, 2013; McIntosh et al., 2016), problemas de salud o lesiones relacionadas con la condición física (Bigal et al., 2007; McIntosh et al., 2016), percepción negativa del peso (Ball et al., 2000; Atlantis & Ball, 2008; Napolitano et al., 2011; McIntosh et al., 2016), estado de ánimo bajo (McIntosh et al., 2016), falta de disfrute durante la práctica de AF (Napolitano et al., 2011; Piana et al., 2013; Peacock et al., 2014; McIntosh et al., 2016), y falta de motivación (Puhl & Heuer, 2009; Napolitano et al., 2011; McIntosh et al., 2016). En cuanto a las barreras externas, éstas coinciden con las barreras que se encuentran en otras poblaciones (McIntosh et al., 2016).

Con el fin de promover la AF y desarrollar intervenciones eficaces dirigidas a aumentar su práctica entre la población, existen distintos modelos y teorías que ya han probado su efectividad y que han ayudado a entender las variables y mecanismos que favorecen la adherencia a la práctica de la AF. Entre estos modelos cabe destacar la teoría cognitivo social (Bandura, 1986), la teoría de la autodeterminación (Decy & Ryan, 1985), el modelo transteórico (Prochasca & DiClemente, 1983), la teoría de la acción razonada (Fishbein & Ajzen, 1975) y el modelo ecológico social (Brofenbrenner, 1976). Muchas de las intervenciones que se han basado en estos modelos y teorías han mostrado su efectividad principalmente a corto plazo. Además, hay algunas barreras que mediante la utilización de estas teorías y modelos, pueden entenderse, pero no pueden combatirse fácilmente.

En este contexto, el uso de la realidad virtual (RV) ya se considera un nuevo método para promover conductas saludables entre las que se encuentra la práctica de la AF (Ahn & Fox, 2017). La RV aplicada al deporte puede definirse como los casos en que las personas practican un deporte representado en un entorno simulado por ordenador que tiene por objetivo inducir una sensación de estar presente mental o físicamente y permite la interactividad con el entorno virtual (Alhadad & Abood, 2018).

La aplicación de la RV al deporte tiene varios puntos fuertes (Alhadad & Abood, 2018) y nos permite superar algunos de los obstáculos más comunes a la hora de practicar AF. Por un lado, la RV permite el control y la manipulación, por lo que puede ser útil para entrenar físicamente a los individuos. La RV puede utilizarse para realizar evaluaciones, obtener información sobre el rendimiento y practicar habilidades específicas. Las actividades deportivas que son peligrosas o costosas para los individuos se pueden llevar a cabo a través de programas de RV. Además, la RV no siempre es individual, sino que permite incluir a otros individuos que se encuentran físicamente en otro lugar. De igual modo, no se requieren conocimientos técnicos especializados para su uso, por lo que los programas de RV pueden utilizarse tanto en gimnasios como en el hogar (Hoffman et al., 2014). Otra ventaja de esta tecnología es que permite superar las posibles influencias ambientales negativas (Plante et al., 2003).

La RV puede ser un medio útil para modificar las actitudes y los comportamientos en las esferas de la atención de la salud, entre las que se encuentra la práctica de la AF. La RV permite una mayor interactividad (mediante la RV el usuario puede interactuar con el entorno virtual en tiempo real, lo que promueve una mejor comprensión por parte del usuario de la relación de causa y efecto entre sus acciones y resultados), y permite la presentación de contenidos de manera multimodal, lo que crea experiencias más convincentes y atractivas para el usuario. Del mismo modo, la RV permite una mayor accesibilidad a la población y es una tecnología intuitiva. Además, se considera que la RV es una tecnología de entretenimiento y uno de los factores que impulsan el cambio de actitud y/o comportamiento está vinculado a la motivación del usuario

(Chow et al., 2017). Finalmente, varios estudios citados en esta tesis muestran cómo la RV puede influir en la motivación hacia la AF, la autoeficacia, el disfrute durante su práctica y la percepción del esfuerzo.

Que la RV es un método útil para promover la práctica de AF es una afirmación consistente en la literatura. Sin embargo, actualmente se está potenciando el estudio de la influencia que tienen los habitantes de los entornos virtuales (agentes y avatares) sobre este efecto. Diversos estudios muestran que la observación e interacción con estas representaciones virtuales permite a los individuos sumergirse en el mundo virtual y llegar a sentir que están realmente presentes en la situación (Ahn et al., 2014; Ahn 2015), aumenta la autoeficacia para alcanzar los objetivos de salud (Ahn et al., 2015) y promueve la reflexión sobre el riesgo para la salud como un hecho importante (Ahn et al., 2014; Ahn, 2015). Además, los comportamientos saludables impulsados por estas representaciones persisten durante más tiempo que la misma información proporcionada por otros canales más tradicionales (Fox, & Bailenson, 2009; Ahn et al., 2014; Ahn, 2015). La literatura muestra que el uso de avatares aumenta los niveles de AF, ya que influyen en la percepción de la actividad, haciéndola más agradable, aumentando la autonomía y la competencia (Thompson et al., 2018).

Durante los últimos años se ha resaltado que la apariencia física del avatar es una variable a considerar (Clark et al, 2019; Peña et al., 2020), y que puede influir en los resultados obtenidos en los ambientes virtuales. En este contexto, actualmente hay dos grandes áreas de estudio. Por una parte, hay estudios que analizan el papel de la personalización de los avatares de acuerdo a las características de los usuarios. Por otra parte, otros estudios analizan características de la apariencia física del avatar relacionadas con estereotipos. Hasta el momento, la literatura ha mostrado, que de acuerdo a la teoría cognitivo social (Bandura, 1986), en general, los participantes que personalizaban sus avatares muestran una mayor intención de cambios conductuales (Clark et al., 2019; Peña et al., 2020). De igual modo, encarnar avatares con ciertas características físicas estereotipadas como son las dimensiones corporales de los avatares

(cuerpo delgado versos sobrepeso) parece influir sobre la práctica de AF. Este último efecto se explicaría por el "Efecto Proteus", el cual predice que los individuos adaptan su comportamiento a la identidad de su avatar y a lo que creen que se espera de su persona virtual (Yee & Bailenson, 2007). Pese a que existen estudios sobre el efecto que tiene la apariencia física del avatar sobre la práctica de AF, los estudios todavía son muy limitados como para hacer conclusiones firmes sobre ello. Actualmente, existe una necesidad de continuar esta línea de investigación para poder llegar a establecer conclusiones firmes así como variables explicativas claras de estos efectos encontrados.

2. Objetivos

La presente tesis doctoral tiene varios objetivos generales. En primer lugar, nuestro interés se centró en el análisis de la motivación hacia la práctica de AF en adolescentes. Para ello, se validó el cuestionario BREQ-2 en población adolescente española y se analizó el papel de la motivación en la práctica de AF en esta población. En segundo lugar, nuestros objetivos se centraron en analizar la influencia de los entornos de RV y las representaciones virtuales de los usuarios sobre la práctica de AF e intervenciones específicas diseñadas para promover este comportamiento. Así pues, los **objetivos generales** son:

1) Validar las propiedades psicométricas de un instrumento destinado a evaluar los diferentes niveles de motivación hacia la AF en la población adolescente española, así como analizar las diferencias de motivación según el sexo y la edad; y el papel de la edad y el sexo en la relación entre la motivación y el disfrute de la AF.
2) Analizar la influencia del uso de la RV para influir en la práctica de la AF y las variables físicas y psicológicas relacionadas con su práctica.
3) Investigar la influencia de la apariencia física del avatar en la práctica de la AF y las variables físicas y psicológicas relacionadas con la práctica.

4) Investigar la efectividad del uso de los avatares para complementar las intervenciones en línea existentes para mejorar la práctica de AF.

3. Metodología y resultados

Para lograr dichos objetivos, se realizaron un estudio psicométrico y correlacional y tres estudios experimentales en el contexto de laboratorio, con un diseño aleatorizado inter-grupo, con dos, tres o cuatro condiciones, en función el estudio.

El estudio 1 tiene como objetivo validar la estructura psicométrica del Cuestionario de Regulación Comportamental en el Ejercicio (BREQ-2) para confirmar la existencia de cinco niveles de motivación hacia la AF en la población adolescente española; así como analizar las diferencias de motivación según sexo y edad; y el papel de la edad y el sexo en la relación entre motivación y disfrute. Los estudios 2, 3 y 4 se centran en analizar como la RV puede promover la práctica de AF. El estudio 2 está diseñado para manipular los resultados de la tarea de AF en un entorno de RV, y analizar sus efectos en varias variables (cansancio subjetivo, afecto, excitación, velocidad y frecuencia cardíaca), así como explorar el papel de moderación de la autoeficacia y la motivación hacia la AF. Mientras que el estudio 3 se dirige a probar cómo los avatares pueden potenciar la práctica de AF, teniendo en cuenta la apariencia física de estos (cara y ropa) y su influencia sobre números de pasos y frecuencia cardiaca. Por último, el estudio 4 se dirige a investigar el uso de avatares y sus variaciones físicas (dimensiones corporales) para potenciar la eficacia de las intervenciones en línea existentes para promover la AF.

Por último, cabe señalar que todos los estudios han ido aprobados por el Comité de Ética de la Universidad de Valencia o la Universidad de Davis (California), y todos los participantes han firmado un consentimiento informado antes de iniciar su participación en el estudio.

3.1. Estudio 1. Propiedades psicométricas del cuestionario de regulación comportamental en el ejercicio físico (BREQ-2) en población adolescente española

El estudio 1 se detalla en el capítulo 2 y se dirige a validar la estructura psicométrica del Cuestionario de Regulación Comportamental en el Ejercicio (BREQ-2). El objetivo principal de este estudio consiste en confirmar la existencia de cinco niveles de motivación hacia la AF en la población adolescente española. Asimismo, los objetivos secundarios de este estudio consisten en: (1) analizar las diferencias de motivación según sexo y edad; (2) analizar el papel de la edad y el sexo en la relación entre motivación y disfrute.

La muestra estuvo compuesta por 666 estudiantes matriculados en escuelas de verano de la Universidad Politécnica de Valencia, la Universidad de Valencia y escuelas secundarias. La edad media osciló entre los 10 y los 16 años (M = 13.03; DT = 1.90) (51.8% mujeres). Se informó a los participantes sobre el estudio y sus padres firmaron el consentimiento informado antes de que los adolescentes rellenaran los cuestionarios. Los estudiantes completaron las medidas en un aula supervisada por asistentes de investigación que estaban disponibles para responder a las preguntas. El tiempo aproximado requerido para completar los instrumentos fue de 35 minutos.

Las medidas tomadas fueron el cuestionario sobre la regulación del comportamiento de la AF (BREQ-2; Markland & Tobin, 2004), la escala de ansiedad hacia la AF y el deporte (PASAS; Norton et al., 2004), la escala de disfrute de la AF (PACES; Motl et al., 2001) y la escala sobre ansiedad física social en la adolescencia (SPAS; Hart et al., 1989).

Se realizó un análisis factorial confirmatorio (CFA) para analizar las propiedades psicométricas del BREQ-2, con una estructura de cinco factores. De igual modo, se evaluó la consistencia interna del BREQ-2 utilizando el coeficiente alfa de Cronbach. Por último, se probó la validez nomológica de las subescalas del BREQ-2 según el SDT (Deci & Ryan, 1985; 2000), y las relaciones encontradas en la literatura entre motivación, disfrute y ansiedad (por ejemplo, Sánchez-Oliva et al., 2014; Sicilia et al., 2014; Thogersen-Ntoumani & Ntoumanis, 2006; Zhang,

2009) a través de las correlaciones de Pearson. Para evaluar la diferencia en la regulación del comportamiento en la AF en función del grupo de edad y el sexo, se realizaron cinco ANOVAs 2x2 con la edad (adolescentes jóvenes -10-13 años-; y adolescentes medios -14-16 años-) y el sexo (niñas y niños) como factores de diferencia. Por último, se realizaron análisis de moderación para examinar si las relaciones entre la regulación intrínseca/introyectada/identificada/externa y el disfrute de la AF estaban moderadas por el sexo o el grupo de edad.

Los resultados mostraron la existencia de una estructura de 5 factores para los tipos de regulación del comportamiento en la AF en la población adolescente española. Los índices de ajuste del CFA indicaron un ajuste adecuado con una estructura de 5 factores: $\chi 2(142) = 530.831$, $p < .001$; CFI = 0.895; TLI = 0.874; RMSEA = 0.064, 90% CI [0.058, 0.070]; GFI = 0.987; SRMR = 0.062. Sin embargo, cabe indicar que el CFA con la estructura de 5 factores se realizó sin el item 17 debido a su baja carga de factores, y los datos empíricos mostraron un buen ajuste al modelo teórico: $\chi 2(125) = 389.946$, $p < 0{,}001$; CFI = 0,926; TLI = 0,909; GFI = 0,991; RMSEA = 0,056, 90% CI [0,050, 0,063]; GFI = 0,991; SRMR = 0,047. Las cargas de factores estandarizados de los elementos del BREQ-2 fueron todas significativas y oscilaron entre .512 y .833. Los valores alfa de Cronbach fueron: regulación intrínseca (α = .823), regulación identificada, (α = .670), regulación introyectada (α = .695), regulación externa (α = .755) y amotivación (α = .672).

Debido a que la consistencia interna era cuestionable para 2 de las subescalas, se realizó un Análisis Factorial Exploratorio (EFA). Kaiser-Meyer-Olkin (KMO = 0,84) y el valor de la Prueba de Esfericidad de Barlett, $\chi 2(171) = 3834{,}80$, $p < 0{,}001$, revelaron que los datos eran apropiados para realizar un análisis factorial. El Análisis Paralelo (Horn, 1965) determinó que debían conservarse 4 factores, con los siguientes índices de ajuste: $\chi 2(101) = 274{,}939$, $p < 0{,}001$; TLI = 0,919; RMSEA = 0,051, 90% CI [0,044-0,058]. La rotación factorial con cuatro factores se llevó a cabo mediante un método oblicuo -y específicamente, oblimino-. Todas las comunidades de ítems tenían valores superiores a 0.30. Las cargas factoriales estandarizadas de los ítems 3, 11 y 17 fueron relativamente bajas y/o mostraron cargas cruzadas en múltiples factores (ítem 3 en

la regulación intrínsecamente identificada = .310; ítem 11 en la regulación externa y amotivación = .414 y .363, respectivamente; y el ítem 17 en la regulación introyectada y amotivación = .397 y .303, respectivamente), pero el resto de los ítems oscilaron entre .418 y .843. Se llevó a cabo otro EFA eliminando los items 3 y 17, ya que el "alfa suprimido de los puntos" mostró que los alfas de Cronbach aumentaban si se suprimían los items 3 y 17 (en el caso del item 3 en la regulación introyectada de α = .841 a α = .843; y en el caso del item 17 en la regulación introyectada de α = .690 a α = .695, y en la amotivación de α = .599 a α = .672). Una vez más, surgió un modelo con 4 dimensiones con los siguientes índices de ajuste: $\chi 2(74) = 227.707$, $p < .001$, TLI = 0,915; RMSEA = 0,056, 90% CI [0,048-0,064]. Se mantuvieron las subescalas de introyección, amotivación y externa, pero las subescalas intrínsecas e identificadas se cargaron en el mismo factor. La consistencia interna del nuevo factor (regulación intrínseca-identificada) fue α = .841.

En cuanto a la validez nomológica, las correlaciones de Pearson se realizaron entre los tipos de regulación del comportamiento en la AF (más el nuevo factor que surgió con la EFA) y los constructos relacionados (es decir, el disfrute de la AF, la ansiedad social en la AF y la ansiedad física social). En cuanto a la intercorrelación entre los tipos de regulación conductual en la AF, los que estaban más cerca en el continuo del SDT estaban positivamente correlacionados: regulación intrínseca e identificada ($r = .61$, $p < .05$); regulación identificada e introyectada ($r = .25$, $p < .05$); regulación introyectada y externa ($r = .29$, $p < .05$); y regulación externa y amotivación ($r = .28$, $p < .05$). Además, los extremos del continuo estaban correlacionados negativamente: regulación intrínseca y externa ($r = -.10$, $p < .05$), regulación intrínseca y amotivación ($r = -.39$, $p < .05$); y regulación identificada y amotivación ($r = -.41$, $p < .05$), aunque la regulación identificada y externa no alcanzaba la significación ($r = -.07$, $p > .05$). El factor regulación intrínseca identificada estaba positivamente correlacionado con la regulación introyectada ($r = .12$, $p < .05$) y negativamente correlacionado con la regulación externa ($r = -.09$, $p < .05$) y la amotivación ($r = -.43$, $p < .05$).

En cuanto a la relación con el disfrute y la ansiedad en la AF, la regulación intrínseca e identificada se correlacionó positivamente con el disfrute (r = .40, p < .05; r = .22, p < .05), pero negativamente con la ansiedad social en la AF (r = -.34, p < .05) y la ansiedad física social (r = -.24, p < .05). Por el contrario, la regulación externa y la amotivación se correlacionaron negativamente con el disfrute (r = -.14, p < .05; r = -.19, p < .05), pero positivamente con la ansiedad social en la AF y la ansiedad física social (r = .28, p < .05; r = .24, p < .05). De manera similar, la regulación introyectada se correlacionó positivamente con la ansiedad social en la AF y la ansiedad física social (r = .22, p < .05; r = .18, p < .05), pero no con el disfrute (r =.02, p > .05).

En cuanto a las diferencias en BREQ-2 por grupo de edad y sexo, hubo un efecto principal del grupo de edad en la regulación intrínseca, $F(1,662) = 53.05$, $p < .001$, $\eta^2p = .07$, y un efecto principal del sexo en la regulación intrínseca, $F(1,662) = 16.94$, $p < .001$, $\eta^2p = .03$. Las comparaciones por pares indicaron que los adolescentes jóvenes mostraron más regulación intrínseca en la AF que los adolescentes medios (p < .001), y los niños mostraron más regulación intrínseca en la AF que las niñas (p < .001). En cuanto a la regulación identificada, hubo un efecto principal del grupo de edad, $F(1,662) = 30.67$, $p < .001$, $\eta^2p = .04$. Los adolescentes jóvenes mostraron más regulación identificada en AF que los adolescentes medios (p < .001). Lo mismo fue encontrado para la regulación externa, donde hubo un efecto principal del grupo de edad, $F(1,662) = 26.40$, $p < .001$, $\eta^2p = .04$, y los adolescentes jóvenes mostraron más regulación externa en la AF que los adolescentes medios (p < .001). También se encontró un efecto principal del grupo de edad en la amotivación, $F(1,662) = 11.98$, $p < .001$, $\eta^2p = .02$. Las comparaciones por pares indicaron que los adolescentes jóvenes mostraron menos amotivación en la AF que los adolescentes medios (p < .001). Hubo un efecto principal del grupo de edad sobre la regulación intrínseca, $F(1,662) = 59.80$, $p < .001$, $\eta^2p = .08$, y un efecto principal del sexo, $F(1,662) = 11.38$, $p < .001$, $\eta^2p = .02$. Finalmente, la interacción entre el grupo de edad y el sexo también fue significativa, $F(1,662) = 4.10$, $p = .043$, $\eta^2p = .01$. Las comparaciones por pares indicaron que los niños mostraron más regulación intrínseca identificada en la AF que las niñas (p < .001), y los

adolescentes jóvenes mostraron más regulación intrínseca identificada en la AF que los adolescentes medios (p < .001). Sin embargo, un efecto de interacción mostró que en la adolescencia media, los niños mostraron significativamente más regulación intrínseca identificada en la EP que las niñas (p < .001).

En cuanto al efecto moderador de la regulación intrínseca/identificada/introyectada/externa sobre el disfrute de la AF por grupo de edad y sexo. Las interacciones entre el grupo de edad y la regulación intrínseca/identificada/introyectada fueron significativas, F(1, 294) = 5.64, p = .018, F(1, 294) = 4.35, p = .038, y F(1, 294) = 10.20, p = .002, representando alrededor del 1.62%, 1.40% y 2.24% de la varianza en el disfrute de la AF, respectivamente. Por lo tanto, el grupo de edad moderó el efecto de la regulación intrínseca/identificada/introyectada sobre el disfrute de la AF. El análisis de las pendientes simples mostró que en los adolescentes jóvenes, hubo relaciones significativas positivas entre la regulación intrínseca y el disfrute de la AF, b = 2.68, 95% CI [01.71, 3.64], t = 5.44, p < .001; y entre la regulación identificada y el disfrute de la AF, b = 1.66, 95% CI [0.80, 2.52], t = 3.81, p < .001. Sin embargo, en los adolescentes medios, hubo una relación significativa negativa entre la regulación introyectada y el disfrute de la AF, b = -1.40, 95% CI [-2.35, -0.45], t = -2.91, p = .004. También se probó la regulación intrínsecamente identificada, y una interacción entre el grupo de edad y este factor también fue significativa, F(1, 294) = 6.46, p = .012, lo que representa el 1.87% de la varianza en el disfrute de la AF. Se encontró una relación significativa positiva entre la regulación intrínseca y el disfrute de la AF, b = 3.04, 95% CI [1.99, 4.09], t = 5.70, p < .001. Se encontraron interacciones no significativas entre el grupo de edad y la regulación externa, o el sexo y los diferentes tipos de regulación en la EP (p's > .05).

En conclusión, este estudio confirma la existencia de una estructura de 5 factores en el cuestionario sobre la regulación del comportamiento en el ejercicio (BREQ-2) en la población adolescente. No obstante, también surgió una estructura de 4 factores con una única regulación intrínsecamente identificada con un ajuste adecuado. De igual modo, este estudio ha

demostrado que los diferentes tipos de regulación de la AF fluctúan en función de la edad y el sexo. Además, este estudio muestra que los tipos de regulación más autodeterminados se asocian positivamente con construcciones psicológicas relacionadas con la práctica de la AF. Por último, este estudio destaca la importancia de fomentar tipos específicos de regulación del comportamiento para aumentar el disfrute en función de la edad con el fin de desarrollar intervenciones de AF.

3.2. Estudio 2. La influencia del éxito o el fracaso en la práctica de la actividad física en los niños: Manipulando el resultado en una tarea de realidad virtual

Este estudio experimental se detalla en el capítulo 3, y está fundamentado en el hecho de que los escenarios de RV pueden crear experiencias exitosas durante la práctica de AF. En este contexto, las experiencias exitosas en entornos de RV pueden aumentar la confianza en sí mismo, el afecto positivo y, en consecuencia, mejorar la AF (Strohacker et al., 2013; Krause & Benavidez, 2014).

El objetivo principal de este estudio consiste en manipular los resultados en una tarea de AF realizada en un entorno de RV, y analizar sus efectos en varias variables relacionadas con la ejecución de la tarea (cansancio subjetivo, afecto, excitación, velocidad y frecuencia cardiaca). Asimismo, el objetivo secundario de este estudio consiste en explorar el papel moderador de la autoeficacia y la motivación hacia la AF sobre los efectos producidos por el entorno de RV.

La muestra estuvo compuesta por 30 niños (*M* = 10.77; *DT* = 1.77), con un índice medio de masa corporal (IMC) de 22.79 (*DT*= 9.33), y que no tenían ningún impedimento para practicar AF. Los participantes fueron asignados al azar a la condición “Experiencia de éxito” o “Experiencia de fracaso”. Primero se recogieron datos antropométricos y sociodemográficos. Después los participantes completaron cuestionarios sobre la motivación (BREQ-2; Markland & Tobin, 2004) y la autoeficacia hacia la AF (Aedo & Ávila, 2009). Finalmente, realizaron la tarea de AF.

A los participantes asignados a la condición “Experiencia de éxito” se les dijo que sus oponentes "virtuales" eran muy rápidos y que la carrera era muy difícil, pero que tenían que intentar ganar. El programa fue manipulado para que los participantes estuvieran por delante de todos sus oponentes y finalmente ganaran la carrera, independientemente de su rendimiento real. A los participantes asignados a la condición “Experiencia de fracaso” se les dijo que sus oponentes "virtuales" eran muy lentos y que la carrera era muy fácil de ganar. El programa fue manipulado para que los participantes estuvieran detrás de todos sus oponentes y perdieran la carrera, sin importar su desempeño real.

Durante la carrera, cada 250 metros, se midió el cansancio subjetivo (EPSE; Eston et al., 2000), el afecto (FS; Hardy & Rejeski, 1989), la excitación (AS; Mehrabian & Russell, 1974), la velocidad y la frecuencia cardiaca (Zephyr HxM Bluetooth). Cuando la carrera terminó, se preguntó a los participantes sobre el resultado de la misma y la razón de su éxito o fracaso. Los participantes que descubrieron el objetivo del estudio fueron excluidos.

Se realizaron ANCOVAs mixtos, utilizando las puntuaciones de la línea base como covariables y análisis de moderación con cada subescala de los instrumentos para examinar si los resultados encontrados en cuanto a cansancio subjetivo, afecto, excitación, frecuencia cardiaca y velocidad estaban moderados por las puntuaciones de autoeficacia y la motivación. Los resultados principales mostraron que los participantes en la condición “Experiencia de éxito” (versus “Experiencia de fracaso”) mostraron, mayor afecto positivo (p = .024), mayor exitacion (p = .043) y mayor velocidad (p = .011). Asimismo, los análisis de moderación mostraron que las "expectativas de habilidad o competencia hacia la AF" en la tarea moderaron el cambio de excitación. El modelo general explicó el 47.88% de la varianza, $F(3,26) = 3,89$, p = .020. La interacción entre la condición y la autoeficacia hacia la AF no incluyó el valor cero en el intervalo de confianza, $F(1,26) = 10.38$, p = .003, 95% CI [3.65, 4.41], indicando que la expectativa de habilidad o competencia hacia la AF fue un moderador del efecto de la condición sobra la excitación, representando el 11.40% de la varianza. Los análisis de los pendientes simples

mostraron que había una relación positiva significativa entre la condición y la excitación cuando la expectativa de habilidad o competencia hacia la AF era "más alta", b = -1.26, 95% CI [-2.26, -0.26], *t* = -2.59, *p* = .015. En el caso de las subescalas de BREQ-2, los análisis de moderación mostraron que la amotivación hacia la AF moderaba el cambio en la excitación. El modelo general explicó el 47.15% de la varianza, *F*(3,24) = 9.44, *p* = .000. La interacción entre la condición y la amotivación no incluyó el valor cero en el intervalo de confianza, *F*(1,24) = 10.59, *p* = .003, 95% CI [3.61 , 4.41], lo que indica que la amotivación hacia la AF fue un moderador del efecto de la condición sobre la excitación, representando el 11.26% de la varianza. Los análisis de pendientes simples mostraron que había una relación positiva entre la condición y la excitación cuando la amotivación era "más baja", b = -0,81, 95% CI [-1,77, 0,15], *t* = -1,72, *p* = .097. Sin embargo, no alcanzó la significación. Además, los análisis de moderación mostraron que la motivación intrínseca hacia la tarea de AF moderaba el cambio de velocidad. En cuanto a la motivación intrínseca hacia la AF, el modelo general explicó el 42.59% de la variación, *F*(3,26) = 3,06, *p* = .046. La interacción entre la condición y la motivación intrínseca no incluyó el valor cero en el intervalo de confianza, *F*(1,26) = 5.09, *p* = .032, 95% CI [15.48, 19.05], indicando que la motivación intrínseca hacia la AF fue un moderador del efecto de la condición en la velocidad, representando el 14.16% de la varianza. Los análisis de las pendientes simples mostraron que había una relación positiva significativa entre la condición y la velocidad cuando la motivación intrínseca era "más alta", b = -5,03, 95% CI [-10,13, 0,06], *t* = -2,03, *p* = .052.

Por tanto, este estudio sugiere que los entornos de RV son útiles para manipular la retroalimentación recibida durante una tarea de AF y por consiguiente, influenciar sobre variables relacionadas con su práctica tales como el afecto, la excitación y la velocidad. De igual modo, hay que resaltar, que hay características relacionadas con el usuario del programa de RV, tales como la autoeficacia o la motivación que pueden influir sobre los efectos esperados del entorno de RV.

3.3. Los efectos de la apariencia física de los avatares en la actividad física: Probando la teoría cognitiva social, el efecto Proteus y las predicciones del gradiente de meta en la frecuencia cardíaca y el conteo de pasos

Este estudio experimental se detalla en el capítulo 4, y está fundamentado en varias teorías y supuestos acerca de la influencia de los avatares sobre la práctica de AF. Por un lado, la literatura ha mostrado que, en congrecuencia con la teoría cognitivo social, para influir en la práctica de la AF, es importante que los avatares muestren la cara del usuario (Fox & Bailenson, 2009). Por otra parte, varios estudios sugieren que el uso de avatares con características físicas estereotipadas también puede influir en la práctica de AF (Clark et al., 2019), lo cual se encuentra vinculado al "Efecto Proteus", que predice que los individuos adaptan su comportamiento a la identidad de su avatar y a lo que creen que se espera de su persona virtual (Yee & Bailenson, 2007). Hasta la fecha, pocos estudios han examinado la intersección entre la teoría cognitiva social y el Efecto Proteus.

El objetivo principal de este estudio consiste en probar las predicciones de la teoría cognitiva social y el efecto Proteus para analizar cómo la exposición a avatares controlados por el usuario que llevaban la cara de los participantes o de extraños mientras usaban ropa deportiva o ropa formal influiría en la práctica de AF (recuento de pasos y frecuencia cardíaca). Además, este estudio examina la dimensión temporal de las intervenciones basadas en los avatares con el objetivo de aumentar la práctica de AF y para ello se basa en la hipótesis del gradiente de meta (Hull, 1932).

La muestra estuvo compuesta por 305 participantes de entre 18 y 37 años (M = 20.02 años; DT = 2.22 años), con un IMC medio (M = 23.21; DT = 4.18), y que no tenían ningún impedimento para practicar AF. Los participantes fueron asignados al azar a la condición de "Cara del participante" o "Cara de un extraño" y "Ropa deportiva" o "Ropa formal". A continuación, los participantes se familiarizaron con un sistema de rastreo de movimiento, el cual mostraba una pista de carrera con su avatar en pantalla mientras que una cámara Kinect

capturaba sus movimientos de brazos, cintura y piernas. A continuación, realizaron la prueba de Cooper, una tarea de AF que consistía en correr lo más lejos posible durante 12 minutos usando acelerómetros y un monitor de frecuencia cardiaca (GT3X and GT9X). Finalmente, cuando terminaron de correr, se midió la altura y el peso y contestaron el cuestionario de identificación con el avatar (Van Looy et al., 2012).

Se realizaron ANOVAS para establecer si los participantes se identificaban con su avatar asignado al azar. La frecuencia cardíaca de los participantes se dividió en tres fases de cuatro minutos (inicio, medio y final) basadas en las 12 mediciones de época de un minuto registradas por el monitor de frecuencia cardíaca. Se creó un promedio de la frecuencia cardíaca de los participantes para cada una de las tres fases. De manera similar, los recuentos de pasos medidos con el acelerómetro de tobillo se promediaron en tres fases de cuatro minutos (inicial, media y final) basadas en las 12 mediciones de intervalos de un minuto. Para establecer si un efecto de gradiente se manifestaba en los datos de AF, la frecuencia cardíaca y el recuento de pasos en las fases inicial, intermedia y final se compararon entre sí utilizando pruebas *t* de muestras emparejadas. Los resultados fueron analizados con ANCOVAs y el IMC fue usado como covariable.

Los resultados principales mostraron que los participantes habían aumentado las puntuaciones de identificación cuando el avatar tenía la cara del participante (versus "La cara de un extraño"), $F(1, 297) = 8.62$, $p = .004$, $\eta^2_p = .028$. Los participantes también mostraron mayores puntuaciones de identificación cuando se les asignó a los avatares vestidos de deporte (versus "Avatares con ropa formal"), $F(1, 297) = 11.11$, $p = .001$, $\eta^2_p = .036$. En cuanto a la frecuencia cardíaca, todos los participantes mostraron frecuencias cardíacas más altas en la fase final ($M = 150.31$, $DT = 29.59$) en relación con las fases inicial ($M = 126.84$, $DT = 37.68$) y media ($M = 143.72$, $DT = 30.83$), $t(282) = 10.438$, $p = .001$, d = .621 y $t(290) = 9.010$, $p = .001$, d = .528, respectivamente. Los participantes también mostraron frecuencias cardiacas más altas en la parte media en relación con la fase inicial, $t(282) = 8.198$, $p = .001$, d = .487. En cuanto al número

de pasos, los participantes mostraron un aumento de pasos en la fase final (*M* = 76.71; *DT* = 11.15) en comparación con las fases inicial (*M* = 74.61; *DT* = 10.02) y media (*M* = 75.59; *DT* = 10.14), *t*(211) = 2.617, *p* = .01, d = .180 y *t*(211) = 2.780, *p* = .006, d = .191, respectivamente. En general, el efecto del gradiente estuvo presente de manera confiable en la frecuencia cardíaca y en el número de pasos de todos los participantes.

Aunque no hubo diferencias para la fase inicial *F*(1, 274) = .294, *p* = .588, η^2_p = . 001, los participantes que fueron asignados al azar a avatares con la cara del propio participante mostraron un aumento de la frecuencia cardíaca en las fases media y final de la tarea de AF en relación con los que fueron asignados a un avatar con la cara de un extraño, Fase media *F*(1, 274) = 5.371, *p* = .021, η^2_p = .019 y fase final *F*(1, 274) = 8.225, *p* = .004, η^2_p = .029. En cuanto al recuento de pasos, aunque no hubo diferencias para las fases inicial y media, hubo un efecto de interacción significativo para los recuentos de pasos en la fase final, fase inicial *F*(1, 203) = 2.657, *p* = .105, η^2_p = .013, fase media *F*(1, 203) = 2.760, *p* = .098, η^2_p = .013, y fase final *F*(1, 203) = 3.930, *p* = .049, η^2_p = .019. Entre los participantes asignados al avatar en ropa deportiva, aquellos que vieron su propio rostro dieron más pasos en la fase final en comparación con los participantes que vieron un avatar con rostro de un extraño, *t*(102) = 1.664, *p* = .045, *d* = .321.

Como se puede observar, este estudio apoya la posibilidad de utilizar modelos de avatares virtuales para fomentar la AF apoyándose en mecanismos psicológicos conocidos como la teoría cognitiva social, el efecto Proteus y la hipótesis del gradiente de meta. Una vez más, se destaca la importancia de personalizar los avatares utilizados en las intervenciones destinadas a aumentar la práctica de la AF.

3.4. Manipulando las dimensiones corporales de los avatares en los mundos virtuales para complementar una intervención en Internet para aumentar la actividad física en las mujeres con sobrepeso

Este estudio experimental se desarrolla en el capítulo 5, y parte de la base de que el uso de avatares con diferentes dimensiones corporales parece ayudar a los individuos a superar las dificultades de representación corporal durante la práctica de la AF (Petkova, & Ehrsson, 2008; Serino et al., 2016) y, en consecuencia, potenciar su práctica (Song et al., 2014).

El objetivo principal de este estudio consistió en analizar la influencia de las dimensiones corporales de los avatares sobre la eficacia de una intervención por Internet para aumentar los niveles de AF y mejorar otras variables relacionadas con su práctica (motivación hacia la AF, disfrute, ansiedad, autoeficacia y establecimiento de objetivos de AF) en mujeres con sobrepeso e insatisfacción corporal.

La muestra estuvo compuesta por 42 mujeres con sobrepeso, con un IMC medio de (*M* = 28.7; DT = 3.1), que eran sedentarias y tenían insatisfacción corporal (Cuestionario de Esquema Corporal -BSQ- >80). Sus edades oscilaban entre los 19 y los 61 años (*M* = 31.9; *DT* = 11.7). Las participantes fueron asignadas al azar a una de las condiciones, "Avatar ideal", "Avatar real" y condición de "No avatar".

En primer lugar, todos los participantes recibieron un correo electrónico con el enlace para rellenar los cuestionarios en línea relacionados con la práctica de AF (IPAQ; Craig et al., 2003), la motivación (BREQ-2; Markland & Tobin, 2004), autoeficacia (ESE; Bandura, 2006), disfrute (PACES; Motl et al., 2001), y ansiedad (PASAS; Norton et al., 2004). Después, los participantes recibieron un enlace con la intervención en línea que debían realizar durante una semana para aumentar la AF. Después de siete días, los participantes fueron invitados individualmente al laboratorio, donde se aplicó la tarea virtual de AF durante unos 10 minutos. La tarea virtual varió en las tres condiciones.

A los participantes de la condición "Avatar ideal" se les pidió que crearan un avatar con sus dimensiones corporales ideales y su propio rostro. A continuación, realizaron una tarea de AF, la cual consistía en correr durante 4 minutos en un escenario de RV donde fueron representados por este avatar. La ejecución de la tarea de RV fue grabada en vídeo, y los

participantes recibieron este vídeo en sus teléfonos móviles y se les pidió que lo vieran todos los días de la semana. Los participantes de la condición "Avatar real" recibieron las mismas instrucciones, pero se les pidió que cambiaran el avatar (con su cara) para que se ajustara a las dimensiones reales de su cuerpo. A los participantes de la condición "No avatar" se les pidió que realizaran la tarea de AF en el escenario de RV durante 4 minutos, pero los participantes no fueron representados por un avatar. Corrieron frente a una imagen fija correspondiente al entorno de RV. No recibieron ninguna grabación de video.

Finalmente, se pidió a todos los participantes que eligieran una meta semanal de AF (caminar o correr tres veces por semana). Una semana más tarde, recibieron un correo electrónico con el enlace para responder los cuestionarios en línea (IPAQ, BREQ-2, ESE, PACES, PASAS e identificación con el avatar de Van Looy et al., 2012). Todos los participantes regresaron al laboratorio para reportar el logro de las metas de AF y recibir su recompensa por completar el estudio.

Se realizaron ANOVAs de medidas repetidas para evaluar la influencia de las dimensiones corporales de los avatares en la AF sobre cada variable (motivación, disfrute, ansiedad, autoeficacia y niveles de AF). Además, se llevaron a cabo ANOVAs univariados para analizar las diferencias entre las condiciones en el tiempo empleado en la intervención, la visualización del video durante la semana, y el logro de las metas de AF. En segundo lugar, para comprobar las diferencias entre las condiciones en el objetivo de AF elegido, se realizó una prueba de chi-cuadrado, utilizando Monte Carlo con 10.000 muestras como un nivel de confianza del 99%. Finalmente, usando el Modelo 6 del PROCESO 3.3, realizamos dos análisis seriados de mediación múltiple para probar si los efectos de la condición en el cambio de AF estaban mediados por la autoeficacia y la similitud percibida con el avatar.

Los resultados revelaron que todos los participantes mostraron niveles más altos de AF después de la intervención, $F(1, 39) = 15.82$, $p = .000$, $\eta^2_p = .29$ y también de autoeficacia hacia la AF, $F(1, 39) = 8.49$, $p = .006$, $\eta^2_p = .18$). De igual modo, todos los participantes mostraron

niveles de ansiedad más bajos durante la AF después de la intervención, $F(1, 39) = 18.18$, $p = .000$, $\eta^2_p = .32$. En cuanto a los niveles de ansiedad, la interacción entre el tiempo y la condición también fue significativa $F(2, 39) = 4.57$, $p = .016$, $\eta^2_p = .19$. Las comparaciones post-hoc usando la corrección de Bonferroni revelaron que los participantes de la condición "Avatar ideal" y la condición "No avatar" mostraron niveles de ansiedad más bajos durante la AF después de la intervención ($p = .010$ y $p = .000$), comparados con los participantes de la condición "Avatar real".

De igual modo, es importante destacar los cambios observados en la condición del "Avatar real". Según los tamaños de efecto estandarizados (Cohen's d), este grupo obtuvo un gran tamaño de efecto (>.80) por su cambio en los niveles de AF, y fue el que más aumentó su práctica semanal. De manera similar, los resultados también mostraron: un tamaño de efecto mediano (<.50) para la motivación intrínseca para estos participantes, quienes aumentaron sus puntuaciones de motivación intrínseca más; un tamaño de efecto grande (>.80) para la motivación externa en los participantes de la condición "Avatar ideal", quienes aumentaron sus puntuaciones de motivación externa más; y un tamaño de efecto grande (>.80) para las expectativas de autoeficacia en los participantes en la condición de "No avatar", quienes aumentaron sus puntuaciones de expectativas de autoeficacia más. Dados estos resultados, aunque a través de este estudio no se pueden concluir diferencias significativas entre los grupos, sería interesante aumentar el poder estadístico del estudio.

Este estudio sugiere que la intervención en línea utilizada en este estudio fue eficaz para aumentar la práctica de la AF y las expectativas de autoeficacia en las mujeres con sobrepeso e insatisfacción corporal. La manipulación de las dimensiones corporales de los avatares no mejoró esta intervención. El uso de avatares ideales parece reducir la ansiedad experimentada durante la AF en esta población. Sin embargo, el uso de avatares similares a la persona misma podría tener un mayor impacto en la AF y las variables relacionadas con su práctica a largo plazo.

4. Conclusiones y discusión

Tal y como se expone a lo largo de la tesis doctoral, promover la práctica de AF entre la población es un objetivo prioritario de salud pública. La RV ha demostrado ser una herramienta útil para promover comportamientos saludables. Sin embargo, con el fin de obtener conclusiones más firmes sobre ello, son necesarios más estudios que analizen la influencia que tienen los entornos virtuales y las representaciones virtuales de los usuarios sobre la práctica de AF y variables tanto físicas como psicológicas relacionadas con su práctica. La presente tesis doctoral surgió de la necesidad de ampliar este campo de estudio.

Para ello, se han llevado a cabo cuatro estudios, uno psicométrico y correlacional y tres experimentales. En los siguientes párrafos se expondrán las conclusiones, respondiendo a cada uno de los objetivos generales de la tesis:

1) *Validar las propiedades psicométricas de un instrumento destinado a evaluar los diferentes niveles de motivación hacia la AF en la población adolescente española, así como analizar las diferencias de motivación según el sexo y la edad; y el papel de la edad y el sexo en la relación entre la motivación y el disfrute de la AF.* Los resultados del estudio 1 confirman la existencia de una estructura de cinco factores en el cuestionario sobre la regulación del comportamiento en el ejercicio (BREQ-2) en la población adolescente española. No obstante, también ha surgido una estructura de cuatro factores con una única regulación intrínsecamente identificada con un ajuste adecuado. De igual modo, este estudio ha demostrado que los diferentes tipos de regulación de la AF fluctúan en función de la edad y el sexo. Además, este estudio muestra que los tipos de regulación más autodeterminados se asocian positivamente con construcciones psicológicas relacionadas con la práctica de la AF. Por último, este estudio destaca la importancia de fomentar tipos específicos de regulación del comportamiento para aumentar el disfrute en función de la edad con el fin de desarrollar intervenciones de AF.

2) *Analizar la influencia del uso de la RV para influir en la práctica de la AF y las variables físicas y psicológicas relacionadas con su práctica.* La respuesta a este objetivo fue otorgada por el estudio 2, cuyos resultados muestran que los entornos de RV son útiles para manipular la retroalimentación recibida durante una tarea de AF y por consiguiente, influenciar sobre variables relacionadas con su práctica tales como el afecto, la excitación y la velocidad. De igual modo, este estudio resalta que hay ciertas características relacionadas con el usuario del programa de RV, tales como la autoeficacia o la motivación que pueden influir sobre los efectos esperados del entorno de RV.

3) *Investigar la influencia de la apariencia física del avatar en la práctica de la AF y las variables físicas y psicológicas relacionadas con la práctica.* Los resultados del estudio 3, apoyan la posibilidad de utilizar modelos de avatares virtuales para fomentar la AF apoyándose en mecanismos psicológicos conocidos como la teoría cognitiva social, el efecto Proteus y la hipótesis del gradiente de meta. Este estudio resalta una vez más la importancia de personalizar los avatares utilizados en las intervenciones destinadas a aumentar la práctica de la AF (por ejemplo, cara y ropa del avatar).

4) *Investigar la efectividad del uso de los avatares para complementar las intervenciones en línea existentes para mejorar la práctica de AF.* Los resultados del estudio 4 sugieren que la intervención en línea utilizada en este estudio es eficaz para aumentar la práctica de la AF y las expectativas de autoeficacia en las mujeres con sobrepeso e insatisfacción corporal. Además, la manipulación de las dimensiones corporales de los avatares no mejora esta intervención. El uso de avatares ideales parece reducir la ansiedad experimentada durante la AF en esta población. Sin embargo, el uso de avatares similares al usuario podría tener un mayor impacto en la AF y las variables relacionadas con su práctica a largo plazo.

La presente tesis doctoral tiene diversas fortalezas que otorgan solidez a los principales resultados. Estas fortalezas son: (1) se estudia un tema muy novedoso en la psicología experimental, clínica y de la salud sobre el que hay pocos estudios y muchas cuestiones por resolver; (2) se analiza el impacto de la RV en la AF en diferentes poblaciones (niños, adultos, población general y población clínica como las mujeres con sobrepeso); (3) desarrolla nuevos entornos de RV; (4) incluye variables relacionadas con la apariencia física del avatar que nunca han sido incluidas en estudios anteriores, como la ropa del avatar y su influencia en la práctica de la AF; (5) analiza si el uso de los avatares y sus variaciones físicas pueden mejorar la eficacia de intervenciones existentes para aumentar el nivel de AF; (6) examina la intersección entre dos teorías que intentan explicar la influencia de los avatares en la práctica de AF, la teoría cognitiva social y el efecto proteus; (7) incluye acelerómetros y monitores de frecuencia cardíaca para medir con mayor precisión la influencia de los avatares en la práctica de AF; y (8) incluye contribuciones de universidades internacionales, la Universidad de Davis, California.

No obstante, la presente tesis doctoral no está exenta de limitaciones. Las limitaciones que son comunes a todos los estudios son: (1) Los sistemas de RV utilizados son semiinmersivos y no siempre se ha medido la inmersión del individuo en el entorno de la RV; (2) aunque se calculó el tamaño mínimo de la muestra necesaria para todos los estudios, no siempre se ha cumplido; (3) no se incluyen medidas de seguimiento en ninguno de los estudios; y (4) no se incluye un grupo de control en todos sus estudios.

Como futuras direcciones, además de subsanar las limitaciones anteriores, sería recomendable: (1) utilizar entornos de RV más inmersivos e incluir siempre esta medida en el protocolo del estudio; (2) incluir características de los individuos, como sus características físicas, sus aptitudes, su experiencia en entornos de RV y sus características psicológicas como variables moderadoras; (3) replicar algunos de los estudios de tesis con tamaños de muestra más grandes y muestras diferentes; (4) hasta la fecha el "verdadero" yo se ha comparado principalmente con el "yo" ideal. Sin embargo, la literatura muestra que el "futuro" yo puede

ser un campo prometedor en el contexto de los comportamientos saludables entre los que se encuentra la práctica de la AF; y (5) incluir dispositivos tecnológicos para medir el movimiento de los ojos del individuo (por ejemplo, el rastreo ocular) mientras interactúa con el entorno de RV.

En conclusión, la presente tesis doctoral proporciona evidencias de que el cuestionario BREQ-2 es una herramienta útil para medir la motivación hacia la AF en la población adolescente española. Además, se confirma una vez más que la motivación hacia la AF es una variable a tener en cuenta para entender el comportamiento de la AF debido, entre otras cosas, a su relación con otras variables que también predicen este comportamiento. En relacion a la aplicación de la RV a la práctica de AF, los resultados señalan que los ambientes de RV son efectivos para manipular la retroalimentación recibida durante una tarea de AF y, consecuentemente, influenciar en las respuestas físicas y psicológicas de la AF (por ejemplo, el afecto, la excitación y la velocidad). De igual modo, se concluye, que los modelos de avatares virtuales pueden alentar la práctica de AF confiando en mecanismos psicológicos conocidos como la teoría cognitiva social, el efecto Proteus y la hipótesis del gradiente de meta. La breve intervención en línea utilizada en esta tesis fue eficaz para aumentar la práctica de AF y las expectativas de autoeficacia en mujeres con sobrepeso e insatisfacción corporal. Sin embargo, en este caso, el uso de avatares y la manipulación de las dimensiones corporales de estos no han mejorado la intervencion. Al parecer, el uso de avatares ideales puede reducir la ansiedad experimentada durante la AF en esta población. Sin embargo, el uso de avatares similares a los de las personas puede tener un mayor impacto en la AF y las variables relacionadas en la práctica a largo plazo.

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SUMMARY IN VALENCIAN /RESUM EN VALENCIÀ

1. Introducció

L'activitat física (AF) pot definir-se com qualsevol moviment corporal produït pels músculs esquelètics que requereix una despesa d'energia (Thivel et al., 2018). Cada vegada hi ha més proves que recolzen els beneficis per a la salut de la AF, per la qual cosa ser físicament actiu és un missatge comú en qualsevol campanya de promoció de la salut (Warburton & Bredin, 2016). D'igual manera, la pràctica de AF està cada vegada més vinculada a la millora del benestar i la salut mental dels individus (Lee & Russell, 2003; Stanton et al., 2014).

Amb la finalitat d'aconseguir tals beneficis, l'organització mundial de la salut (OMS) proposa una sèrie de recomanacions a nivell mundial, d'acord amb l'edat dels individus (OMS, 2010). Malgrat els beneficis que la pràctica de AF proporciona en els individus i de l'increment de campanyes que es posen en marxa per a promoure la seua pràctica, encara gran part de la població no compleix amb els mínims recomanats. De fet, Espanya és el huité país de la Unió Europea en el seu conjunt i el cinqué país d'Europa en el qual el major percentatge de la població no compleix les recomanacions mínimes de l'OMS (Mayo, 2017).

Segons l'OMS (2010), la inactivitat física és una pandèmia mundial que s'ha convertit en una de les principals causes de mort en el món. De fet, constitueix el quart factor de risc més important de mortalitat (OMS, 2010). D'igual manera, s'ha considerat la inactivitat física com un dels principals contribuents als costos de l'atenció de la salut i a la pèrdua de productivitat d'un país (Kruk, 2014). És per aquest motiu, que es considera necessari continuar desenvolupant intervencions dirigides a promoure la pràctica de AF entre la població.

La literatura mostra que hi ha múltiples barreres a superar si es vol aconseguir promoure la pràctica de AF. Hesketh et al. (2017) conclouen que la AF i el comportament sedentari entre els 0 i 6 anys estàn associats a les seues preferències personals, el seu nivell de desenvolupament, la seua salut, el paper que els pares adquireixen en aquest tema així com els germans i companys més pròxims, l'ambient on el xiquet es desenvolupa, la seguretat del xiquet i el clima de la ciutat on viuen. De totes aquestes variables, aquests autors conclouen, que les

barreres i els facilitadors interpersonals (per exemple, els pares, els cuidadors i la família) són les més importants a tindre en compte en els xiquets d'aquestes edats.

Altres autors, com Rees et al. (2006), afirmen que en els xiquets d'11 a 16 anys mostren barreres en la mateixa línia que els resultats oposats en poblacions més joves, com les interpersonals (per exemple, l'escola, la família i els amics) i l'existència de recursos pràctics i materials com el temps i els diners. No obstant això, aquests autors identifiquen la rellevància d'una mena de barrera addicional relacionada amb el individu (per exemple, la falta de confiança en les pròpies habilitats, els sentiments d'incomoditat durant la AF, la falta de motivació, la preferència per altres habilitats, la falta de coneixement sobre els beneficis de la AF i l'autoconsciència sobre el cos i l'aparença física).

En relació amb la població adolescent entre 13 i 18 anys d'edat, Martins et al. (2015) conclouen l'existència de barreres com ara una mala actitud cap a la AF, falta de motivació, falta de gaudi, baixa percepció de competència, preocupacions sobre la imatge corporal, percepció de la feminitat i normes socials incompatibles amb la pràctica de AF, falta de temps, influències socials negatives (per exemple, de la família, amics o mestres), falta d'oportunitats relacionades amb el lloc on viuen (per exemple, infraestructura, transport o seguretat) i períodes de vida associats amb els canvis (per exemple, el canvi de l'escola primària a l'escola secundària o de l'escola secundària al món del treball).

En relació a la població adulta, les principals variables que s'han considerat com a barreres per a la pràctica de la AF han sigut principalment la falta de motivació, la falta de temps (Cerin et al., 2010; Justine et al.,2013; Herazo-Beltran et al., 2017; Hoare et al., 2017), falta de suport social en la pràctica (Justine et al., 2013; Herazo-Beltrán et al., 2017; Hoare et al., 2017), els problemes de salut, la falta d'energia o la por a les lesions (Cerin et al., 2010; Moschny et al., 2011; Herazo-Beltrán et al., 2017; Schoeny et al., 2017), falta d'habilitats (Justine et al., 2013; Herazo-Beltran et al., 2017; Hoare et al., 2017), absència de gaudi (Hoare et al., 2017) i falta de recursos (Cerin et al., 2010; Moschny et al., 2011; Justine et al., 2013; Herazo-Beltran et al., 2017;

Schoeny et al., 2017). En general, les barreres cap a la AF són comunes a tots dos gèneres. No obstant això, hi ha una barrera que apareix amb major freqüència entre la població femenina, la preocupació per la imatge corporal. Les dones experimenten una major autoconsciència de la seua aparença física durant la AF (Robbins et al., 2003). Aquesta major consciència de si mateixa les fa menys propenses a participar en la AF (Slater & Tiggemann, 2011).

En relació amb la població amb sobrepés o obesitat, la literatura mostra l'existència de barreres internes per a l'individu com el propi sobrepés (Hulens et al., 2001; Egan et al., 2013; McIntosh et al., 2016), problemes de salut o lesions relacionades amb la condició física (Bigal et al., 2007; McIntosh et al., 2016), percepció negativa del pes (Ball et al., 2000; Atlantis & Ball, 2008; Chen et al., 2010; Napolità et al., 2011; McIntosh et al., 2016), estat d'ànim baix (McIntosh et al., 2016), falta de gaudi durant la pràctica de AF (Napolitano et al., 2011; Piana et al., 2013; Peacock et al.,2014; McIntosh et al., 2016), i falta de motivació (Puhl & Heuer, 2009; Napolitano et al., 2011; McIntosh et al.,2016). Quant a les barreres externes, aquestes coincideixen amb les barreres que es troben en altres poblacions (McIntosh et al., 2016).

Amb la finalitat de promoure la AF i desenvolupar intervencions eficaces dirigides a augmentar la seua pràctica entre la població, existeixen diferents models i teories que ja han provat la seua efectivitat i que han ajudat a entendre les variables i mecanismes que afavoreixen l'adherència a la pràctica de la AF. Entre aquests models cal destacar la teoria cognitiu social (Bandura, 1986), la teoria de l'autodeterminació (Decy & Ryan, 1985), el model transteóric (Prochasca & DiClemente, 1983), la teoria de l'acció raonada (Fishbein & Ajzen, 1975) i el model ecològic social (Brofenbrenner, 1976). Moltes de les intervencions que s'han basat en aquests models i teories han mostrat la seua efectivitat principalment a curt termini. A més, hi ha algunes barreres que mitjançant la utilització d'aquestes teories i models, poden entendre's, però no poden combatre's fàcilment.

En aquest context, l'ús de la realitat virtual (RV) ja es considera un nou mètode per a promoure conductes saludables entre les quals es troba la pràctica de la AF (Ahn & Fox, 2017).

La RV aplicada a l'esport pot definir-se com els casos en què les persones practiquen un esport representat en un entorn simulat per ordinador que té per objectiu induir una sensació d'estar present mental o físicament i permet la interactivitat amb l'entorn virtual (Alhadad & Abood, 2018).

L'aplicació de la RV a l'esport té diversos punts forts (Alhadad & Abood, 2018) i ens permet superar alguns dels obstacles més comuns a l'hora de practicar AF. D'una banda, la RV permet el control i la manipulació, per la qual cosa pot ser útil per a entrenar físicament als individus. La RV pot utilitzar-se per a realitzar avaluacions, obtindre informació sobre el rendiment i practicar habilitats específiques. Les activitats esportives que són perilloses o costoses per als individus es poden dur a terme a través de programes de RV. A més, la RV no sempre és individual, sinó que permet incloure a altres individus que es troben físicament en un altre lloc. D'igual manera, no es requereixen coneixements tècnics especialitzats per al seu ús, per la qual cosa els programes de RV poden utilitzar-se tant en gimnasos com en la llar (Hoffman et al., 2014). Un altre avantatge d'aquesta tecnologia és que permet superar les possibles influències ambientals negatives (Plante et al., 2003).

La RV pot ser un mitjà útil per a modificar les actituds i els comportaments en les esferes de l'atenció de la salut, entre les quals es troba la pràctica de la AF. La RV permet una major interactivitat (mitjançant la RV l'usuari pot interactuar amb l'entorn virtual en temps real, la qual cosa promou una millor comprensió per part de l'usuari de la relació de causa i efecte entre les seues accions i resultats), i permet la presentació de continguts de manera multimodal, la qual cosa crea experiències més convincents i atractives per a l'usuari. De la mateixa manera, la RV permet una major accessibilitat a la població i és una tecnologia intuïtiva. A més, es considera que la RV és una tecnologia d'entreteniment i un dels factors que impulsen el canvi d'actitud i/o comportament està vinculat a la motivació de l'usuari (Chow et al., 2017). Finalment, diversos estudis citats en aquesta tesi mostren com la RV pot influir en la motivació cap a la AF, l'autoeficàcia, el gaudi durant la seua pràctica i la percepció de l'esforç.

Que la RV és un mètode útil per a promoure la pràctica de AF és una afirmació consistent en la literatura. No obstant això, actualment s'està potenciant l'estudi de la influència que tenen els habitants dels entorns virtuals (agents i avatars) sobre aquest efecte. Diversos estudis mostren que l'observació i interacció amb aquestes representacions virtuals permet als individus submergir-se en el món virtual i arribar a sentir que estan realment presents en la situació (Ahn et al., 2014; Ahn 2015), augmenta l'autoeficàcia per a aconseguir els objectius de salut (Ahn et al., 2015) i promou la reflexió sobre el risc per a la salut com un fet important (Ahn et al., 2014; Ahn, 2015). A més, els comportaments saludables impulsats per aquestes representacions persisteixen durant més temps que la mateixa informació proporcionada per altres canals més tradicionals (Fox, & Bailenson, 2009; Ahn et al., 2014; Ahn, 2015). La literatura mostra que l'ús d'avatars augmenta els nivells de AF, ja que influeixen en la percepció de l'activitat, fent-la més agradable, augmentant l'autonomia i la competència (Thompson et al., 2018).

Durant els últims anys s'ha ressaltat que l'aparença física de l'avatar és una variable a considerar (Clark et al., 2019; Peña et al., 2020), i que pot influir en els resultats obtinguts en els ambients virtuals. En aquest context, actualment hi ha dues grans àrees d'estudi. D'una banda, hi ha estudis que analitzen el paper de la personalització dels avatars d'acord amb les característiques dels usuaris. D'altra banda, altres estudis analitzen característiques de l'aparença física de l'avatar relacionades amb estereotips. Fins al moment, la literatura ha mostrat, que d'acord amb la teoria cognitiu social (Bandura, 1986), en general, els participants que personalitzaven els seus avatars mostren una major intenció de canvis conductuals (Clark et al., 2019; Peña et al., 2020). D'igual manera, encarnar avatars amb certes característiques físiques estereotipades com són les dimensions corporals dels avatars (cos prim versos sobrepés) sembla influir sobre la pràctica de AF. Aquest últim efecte s'explicaria per el “Efecte Proteo”, el qual prediu que els individus adapten el seu comportament a la identitat del seu avatar i al que creuen que s'espera de la seua persona virtual (Yee & Bailenson, 2007). Malgrat que existeixen estudis sobre l'efecte que té l'aparença física de l'avatar sobre la pràctica de AF,

els estudis encara són molt limitats com per a fer conclusions fermes sobre això. Actualment, existeix una necessitat de continuar aquesta línia d'investigació per a poder arribar a establir conclusions fermes així com variables explicatives clares d'aquests efectes oposats.

2. Objectius

La present tesi doctoral té com diversos objectius generals. En primer lloc, el nostre interés es va centrar en l'anàlisi de la motivació per a la pràctica de la AF en adolescents. Per a això, es va validar el qüestionari BREQ-2 en població adolescent espanyola i així es com va analitzar el paper de la motivació en la pràctica de AF en aquesta població. En segon lloc, els nostres objectius es van centrar en analitzar la influència dels entorns de RV i les representacions virtuals dels usuaris sobre la pràctica de AF i intervencions específiques dissenyades per a promoure aquest comportament. Així doncs, els **objectius generals** són:

1) Validar les propietats psicomètriques d'un instrument destinat a avaluar els diferents nivells de motivació cap a la AF en la població adolescent espanyola, així com analitzar les diferències de motivació segons el sexe i l'edat; i el paper de l'edat i el sexe en la relació entre la motivació i el gaudi de la AF.

2) Analitzar la influència de l'ús de la RV per a influir en la pràctica de la AF i les variables físiques i psicològiques relacionades amb la seua pràctica.

3) Investigar la influència de l'aparença física de l'avatar en la pràctica de la AF i les variables físiques i psicològiques relacionades amb la pràctica.

4) Investigar l'efectivitat de l'ús dels avatars per a complementar les intervencions en línia existents per a millorar la pràctica de AF.

3. Metodología i resultats

Per a aconseguir aquests objectius, es van realitzar un estudi psicomètric i correlacional i tres estudis experimentals en el context de laboratori, amb un disseny aleatoritzat inter-grup, amb dos, tres o quatre condicions, en funció l'estudi.

L'estudi 1 té com a objectiu validar l'estructura psicomètrica del Qüestionari de Regulació Comportamental en l'Exercici (BREQ-2) per a confirmar l'existència de cinc nivells de motivació cap a la AF en la població adolescent espanyola; així com analitzar les diferències de motivació segons sexe i edat; i el paper de l'edat i el sexe en la relació entre motivació i gaudi. Els estudis 2, 3 i 4 se centren en analitzar com la RV pot promoure la pràctica de AF. L'estudi 2 està dissenyat per a manipular els resultats de la tasca de AF en un entorn de RV, i analitzar els seus efectes en diverses variables (cansament subjectiu, afecte, excitació, velocitat i freqüència cardíaca), així com explorar el paper de moderació de l'autoeficàcia i la motivació cap a la AF. Mentre que l'estudi 3 es dirigeix a provar com els avatars poden potenciar la pràctica de AF, tenint en compte l'aparença física d'aquests (cara i roba) i la seua influència sobre nombres de passos i freqüència cardíaca. Finalment, l'estudi 4 es dirigeix a investigar l'ús d'avatars i les seues variacions físiques (dimensions corporals) per a potenciar l'eficàcia de les intervencions en línia existents per a promoure la AF.

Finalment, cal assenyalar que tots els estudis han anat aprovats pel Comité d'Ètica de la Universitat de València o la Universitat de Davis (Califòrnia), i tots els participants han signat un consentiment informat abans d'iniciar la seua participació en l'estudi.

3.1. Estudi 1. Propietats psicomètriques del qüestionari de regulació comportamental en l'exercici físic (BREQ-2) en població adolescent espanyola

L'estudi 1 es detalla en el capítol 2 i es dirigeix a validar l'estructura psicomètrica del Qüestionari de Regulació Comportamental en l'Exercici (BREQ-2). L'objectiu principal d'aquest estudi consisteix a confirmar l'existència de cinc nivells de motivació cap a la AF en la població

adolescent espanyola. Així mateix, els objectius secundaris d'aquest estudi consisteixen en: (1) analitzar les diferències de motivació segons sexe i edat; (2) analitzar el paper de l'edat i el sexe en la relació entre motivació i gaudi.

La mostra va estar composta per 666 estudiants matriculats en escoles d'estiu de la Universitat Politècnica de València, la Universitat de València i escoles secundàries. L'edat mitjana va oscil·lar entre els 10 i els 16 anys (*M* = 13.03; *DT* = 1.90) (51.8% dones). Es va informar els participants sobre l'estudi i els seus pares van signar el consentiment informat abans que els adolescents emplenaren els qüestionaris. Els estudiants van completar les mesures en una aula supervisada per assistents d'investigació que estaven disponibles per a respondre a les preguntes. El temps aproximat requerit per a completar els instruments va ser de 35 minuts.

Les mesures preses van ser el qüestionari sobre la regulació del comportament de la AF (BREQ-2; Markland & Tobin, 2004), l'escala d'ansietat cap a la AF i l'esport (PASAS; Norton et al., 2004), l'escala de gaudi de AF (PACES; Motl et al., 2001) i l'escala sobre ansietat física social en l'adolescència (SPAS; Hart et al., 1989).

Es va realitzar una anàlisi factorial confirmatòria (CFA) per a analitzar les propietats psicomètriques del BREQ-2, amb una estructura de cinc factors. D'igual manera, es va avaluar la consistència interna del BREQ-2 utilitzant el coeficient alfa de Cronbach. Finalment, es va provar la validesa nomológica de les subescales del BREQ-2 segons el SDT (Deci & Ryan, 1985; 2000; 2007), i les relacions oposades en la literatura entre motivació, gaudi i ansietat (per exemple, Sánchez-Oliva et al., 2014; Sicília et al., 2014; Thogersen-Ntoumani & Ntoumanis, 2006; Zhang, 2009) a través de les correlacions de Pearson. Per a avaluar la diferència en la regulació del comportament en la AF en funció del grup d'edat i el sexe, es van realitzar cinc ANOVAs 2x2 amb l'edat (adolescents joves -10-13 anys-; i adolescents mitjans -14-16 anys-) i el sexe (xiquetes i xiquets) com a factors de diferència. Finalment, es van realitzar anàlisi de moderació per a examinar si les relacions entre la regulació intrínseca/introyectada/identificada/externa i el gaudi de la AF estaven moderades pel sexe o el grup d'edat.

Els resultats van mostrar l'existència d'una estructura de 5 factors per als tipus de regulació del comportament en la AF en la població adolescent espanyola. Els índexs d'ajust del CFA van indicar un ajust adequat amb una estructura de 5 factors: $\chi 2(142) = 530.831$, $p < .001$; CFI = 0.895; TLI = 0.874; RMSEA = 0.064, 90% CI [0.058, 0.070]; GFI = 0.987; SRMR = 0.062. No obstant això, cal indicar que el CFA amb l'estructura de 5 factors es va realitzar sense el item 17 a causa de la seua baixa càrrega de factors, i les dades empíriques van mostrar un bon ajust al model teòric: $\chi 2(125) = 389.946$, $p < 0.001$; CFI = 0.926; TLI = 0,909; GFI = 0.991; RMSEA = 0.056, 90% CI [0,050, 0,063]; GFI = 0.991; SRMR = 0.047. Les càrregues de factors estandarditzats dels elements del BREQ-2 van ser totes significatives i van oscil·lar entre .512 i .833. Els valors alfa de Cronbach van ser: regulació intrínseca (α = .823), regulació identificada, (α = .670), regulació introyectada (α = .695), regulació externa (α = .755) i amotivación (α = .672).

Pel fet que la consistència interna era qüestionable per a 2 de les subescales, es va realitzar una Anàlisi Factorial Exploratòria (EFA). Kaiser-Meyer-Olkin (KMO = 0.84) i el valor de la Prova d'Esfericitat de Barlett, $\chi 2(171) = 3834.80$, $p < 0.001$, van revelar que les dades eren apropiades per a realitzar una anàlisi factorial. L'Anàlisi Paral·lela (Horn, 1965) va determinar que havien de conservar-se 4 factors, amb els següents índexs d'ajust: $\chi 2(101) = 274.939$, $p < 0.001$; TLI = 0.919; RMSEA = 0.051, 90% CI [0.044-0.058]. La rotació factorial amb quatre factors es va dur a terme mitjançant un mètode oblic -i específicament, oblimino-. Totes les comunitats d'ítems tenien valors superiors a 0.30. Les càrregues factorials estandarditzades dels ítems 3, 11 i 17 van ser relativament baixes i/o van mostrar càrregues creuades en múltiples factors (ítem 3 en la regulació intrínsecament identificada = .310; ítem 11 en la regulació externa i amotivación = .414 i .363, respectivament; i l'ítem 17 en la regulació introyectada i amotivación = .397 i .303, respectivament), però la resta dels ítems van oscil·lar entre .418 i .843. Es va dur a terme un altre EFA eliminant els items 3 i 17, ja que l'"alfa suprimit dels punts" va mostrar que els alfes de Cronbach augmentaven si se suprimien els items 3 i 17 (en el cas del item 3 en la regulació introyectada de α = .841 a α = .843; i en el cas del item 17 en la regulació introyectada de α =

.690 a α = .695, i en la amotivación de α = .599 a α = .672). Una vegada més, va sorgir un model amb 4 dimensions amb els següents índexs d'ajust: $\chi 2(74) = 227.707$, $p < .001$, TLI = 0.915; RMSEA = 0.056, 90% CI [0.048-0.064]. Es van mantindre les subescales de introyección, amotivación i externa, però les subescales intrínseques i identificades es van carregar en el mateix factor. La consistència interna del nou factor (regulació intrínseca-identificada) va ser α = .841.

Quant a la validesa nomológica, les correlacions de Pearson es van realitzar entre els tipus de regulació del comportament en la AF (més el nou factor que va sorgir amb la EFA) i els constructes relacionats (és a dir, el gaudi de la AF, l'ansietat social en la AF i l'ansietat física social). Quant a la intercorrelación entre els tipus de regulació conductual en la AF, els que estaven més a prop en el continu del SDT estaven positivament correlacionats: regulació intrínseca i identificada ($r = .61$, $p < .05$); regulació identificada i introyectada ($r = .25$, $p < .05$); regulació introyectada i externa ($r = .29$, $p < .05$); i regulació externa i amotivación ($r = .28$, $p < .05$). A més, els extrems del continu estaven correlacionats negativament: regulació intrínseca i externa ($r = -.10$, $p < .05$), regulació intrínseca i amotivación ($r = -.39$, $p < .05$); i regulació identificada i amotivación ($r = -.41$, $p < .05$), encara que la regulació identificada i externa no aconseguia la significació ($r = -.07$, $p > .05$). El factor regulació intrínseca identificada estava positivament correlacionat amb la regulació introyectada ($r = .12$, $p < .05$) i negativament correlacionat amb la regulació externa ($r =-.09$, $p < .05$) i la amotivación ($r = -.43$, $p < .05$).

Quant a la relació amb el gaudi i l'ansietat en la AF, la regulació intrínseca i identificada es va correlacionar positivament amb el gaudi ($r = .40$, $p < .05$; $r = .22$, $p < .05$), però negativament amb l'ansietat social en la AF ($r = -.34$, $p < .05$) i l'ansietat física social ($r = -.24$, $p < .05$). Per contra, la regulació externa i la amotivación es van correlacionar negativament amb el gaudi ($r = -.14$, $p < .05$; $r = -.19$, $p < .05$), però positivament amb l'ansietat social en la AF i l'ansietat física social ($r = .28$, $p < .05$; $r = .24$, $p < .05$). De manera similar, la regulació introyectada es va correlacionar

positivament amb l'ansietat social en la AF i l'ansietat física social (r = .22, p < .05; r = .18, p < .05), però no amb el gaudi (r =.02, p > .05).

Quant a les diferències en BREQ-2 per grup d'edat i sexe, Va haver-hi un efecte principal del grup d'edat en la regulació intrínseca, $F(1,662) = 53.05$, $p < .001$, $\eta^2_p = .07$, i un efecte principal del sexe en la regulació intrínseca, $F(1,662) = 16.94$, $p < .001$, $\eta^2_p = .03$. Les comparacions per parells van indicar que els adolescents joves van mostrar més regulació intrínseca en la AF que els adolescents mitjans (p < .001), i els xiquets van mostrar més regulació intrínseca en la AF que les xiquetes (p < .001). Quant a la regulació identificada, va haver-hi un efecte principal del grup d'edat, $F(1,662) = 30.67$, $p < .001$, $\eta^2_p = .04$. Els adolescents joves van mostrar més regulació identificada en AF que els adolescents mitjans (p < .001). El mateix va ser trobat per a la regulació externa, on va haver-hi un efecte principal del grup d'edat, $F(1,662) = 26.40$, $p < .001$, $\eta^2_p = .04$, i els adolescents joves van mostrar més regulació externa en la AF que els adolescents mitjans (p < .001). També es va trobar un efecte principal del grup d'edat en la amotivación, $F(1,662) = 11.98$, $p < .001$, $\eta^2_p = .02$. Les comparacions per parells van indicar que els adolescents joves van mostrar menys amotivación en la AF que els adolescents mitjans (p < .001). Va haver-hi un efecte principal del grup d'edat sobre la regulació intrínseca, $F(1,662) = 59.80$, $p < .001$, $\eta^2_p = .08$, i un efecte principal del sexe, $F(1,662) = 11.38$, $p < .001$, $\eta^2_p = .02$. Finalment, la interacció entre el grup d'edat i el sexe també va ser significativa, $F(1,662) = 4.10$, $p = .043$, $\eta^2_p = .01$. Les comparacions per parells van indicar que els xiquets van mostrar més regulació intrínseca identificada en la AF que les xiquetes (p < .001), i els adolescents joves van mostrar més regulació intrínseca identificada en la AF que els adolescents mitjans (p < .001). No obstant això, un efecte d'interacció va mostrar que en l'adolescència mitjana, els xiquets van mostrar significativament més regulació intrínseca identificada en la EP que les xiquetes (p < 0,001).

Quant a l'efecte moderador de la regulació intrínseca/identificada/introyectada/externa sobre el gaudi de la AF per grup d'edat i sexe. Les interaccions entre el grup d'edat i la regulació intrínseca/identificada/introyectada van ser significatives, $F(1, 294) = 5.64$, $p = .018$, $F(1,294) =$

4.35, p = .038, i F(1, 294) = 10.20, p = .002, representant al voltant del 1.62%, 1.40% i 2.24% de la variància en el gaudi de la AF, respectivament. Per tant, el grup d'edat va moderar l'efecte de la regulació intrínseca/identificada/introyectada sobre el gaudi de la AF. L'anàlisi dels pendents simples va mostrar que en els adolescents joves, va haver-hi relacions significatives positives entre la regulació intrínseca i el gaudi de la AF, b = 2.68, 95% CI [01.71, 3.64], t = 5.44, p < .001; i entre la regulació identificada i el gaudi de la AF, b = 1.66, 95% CI [0.80, 2.52], t = 3.81, p < .001. No obstant això, en els adolescents mitjans, va haver-hi una relació significativa negativa entre la regulació introyectada i el gaudi de la AF, b = -1.40, 95% CI [-2.35, -0.45], t = -2.91, p = .004. També es va provar la regulació intrínsecament identificada, i una interacció entre el grup d'edat i aquest factor també va ser significativa, F(1, 294) = 6.46, p = .012, la qual cosa representa el 1.87% de la variància en el gaudi de la AF. Es va trobar una relació significativa positiva entre la regulació intrínseca i el gaudi de la AF, b = 3.04, 95% CI [1.99, 4.09], t = 5.70, p < .001. Es van trobar interaccions no significatives entre el grup d'edat i la regulació externa, o el sexe i els diferents tipus de regulació en la EP ($p's$ > .05).

En conclusió, aquest estudi confirma l'existència d'una estructura de 5 factors en el qüestionari sobre la regulació del comportament en l'exercici (BREQ-2) en la població adolescent. No obstant això, també va sorgir una estructura de 4 factors amb una única regulació intrínsecament identificada amb un ajust adequat. D'igual manera, aquest estudi ha demostrat que els diferents tipus de regulació de la AF fluctuen en funció de l'edat i el sexe. A més, aquest estudi mostra que els tipus de regulació més autodeterminados s'associen positivament amb construccions psicològiques relacionades amb la pràctica de la AF. Finalment, aquest estudi destaca la importància de fomentar tipus específics de regulació del comportament per a augmentar el gaudi en funció de l'edat amb la finalitat de desenvolupar intervencions de AF.

3.2. Estudi 2. La influència de l'èxit o el fracàs en la pràctica de l'activitat física en els xiquets: Manipulant el resultat en una tasca de realitat virtual

Aquest estudi experimental es detalla en el capítol 3, i està fonamentat en el fet que els escenaris de RV poden crear experiències reeixides durant la pràctica de AF. En aquest context, les experiències reeixides en entorns de RV poden augmentar la confiança en si mateix, l'afecte positiu i, en conseqüència, millorar la AF (Strohacker et al., 2013; Krause & Benavidez, 2014).

L'objectiu principal d'aquest estudi consisteix a manipular els resultats en una tasca de AF realitzada en un entorn de RV, i analitzar els seus efectes en diverses variables relacionades amb l'execució de la tasca (cansament subjectiu, afecte, excitació, velocitat i freqüència cardíaca). Així mateix, l'objectiu secundari d'aquest estudi consisteix a explorar el paper moderador de l'autoeficàcia i la motivació cap a la AF sobre els efectes produïts per l'entorn de RV.

La mostra va estar composta per 30 xiquets (*M* = 10.77; *DT* = 1.77), amb un índex mitjà de massa corporal (IMC) de 22.79 (*DT*= 9.33), i que no tenien cap impediment per a practicar AF. Els participants van ser assignats a l'atzar a la condició "Experiència d'èxit" o "Experiència de fracàs". Primer es van recollir dades antropomètriques i sociodemogràfiques. Després els participants van completar qüestionaris sobre la motivació (BREQ-2; Markland & Tobin, 2004) i l'autoeficàcia cap a la AF (Aedo & Àvila, 2009). Finalment, van fer la tasca de AF.

Als participants assignats a la condició "Experiència d'èxit" se'ls va dir que els seus oponents "virtuals" eren molt ràpids i que la carrera era molt difícil, però que havien d'intentar guanyar. El programa va ser manipulat perquè els participants estigueren per davant de tots els seus oponents i finalment guanyaren la carrera, independentment del seu rendiment real. Als participants assignats a la condició "Experiència de fracàs" se'ls va dir que els seus oponents "virtuals" eren molt lents i que la carrera era molt fàcil de guanyar. El programa va ser manipulat perquè els participants estigueren darrere de tots els seus oponents i perderen la carrera, sense importar el seu acompliment real.

Durant la carrera, cada 250 metres, es va mesurar el cansament subjectiu (EPSE; Eston et al., 2000), l'afecte (FS; Hardy & Rejeski, 1989), l'excitació (AS; Mehrabian & Russell, 1974), la velocitat i la freqüència cardíaca (Zephyr HxM Bluetooth). Quan la carrera va acabar, es va

preguntar als participants sobre el resultat de la mateixa i la raó del seu èxit o fracàs. Els participants que van descobrir l'objectiu de l'estudi van ser exclosos.

Es van realitzar ANCOVAs mixtos, utilitzant les puntuacions de la línia base com covariables i anàlisi de moderació amb cada subescala dels instruments per a examinar si els resultats oposats quant a cansament subjectiu, afecte, excitació, freqüència cardíaca i velocitat estaven moderats per les puntuacions d'autoeficàcia i la motivació. Els resultats principals van mostrar que els participants en la condició “Experiència d'èxit” (versus “Experiència de fracàs”) van mostrar, major afecte positiu (p = .024), major excitació (p = .043) i major velocitat (p = .011). Així mateix, les anàlisis de moderació van mostrar que les "expectatives d'habilitat o competència cap a la AF" en la tasca van moderar el canvi d'excitació. El model general va explicar el 47.88% de la variància, F(3,26) = 3.89, p = .020. La interacció entre la condició i l'autoeficàcia cap a la AF no va incloure el valor zero en l'interval de confiança, F(1,26) = 10.38, p = .003, 95% CI [3.65, 4.41], indicant que l'expectativa d'habilitat o competència cap a la AF va ser un moderador de l'efecte de la condició sobra l'excitació, representant el 11.40% de la variància. Les anàlisis de les arracades simples van mostrar que hi havia una relació positiva significativa entre la condició i l'excitació quan l'expectativa d'habilitat o competència cap a la AF era "més alta", b = -1.26, 95% CI [-2.26, -0.26], t = -2.59, p = .015. En el cas de les subescales de BREQ-2, les anàlisis de moderació van mostrar que la amotivación cap a la AF moderava el canvi en l'excitació. El model general va explicar el 47.15% de la variància, F(3,24) = 9.44, p = .000. La interacció entre la condició i la amotivación no va incloure el valor zero en l'interval de confiança, F(1,24) = 10.59, p = .003, 95% CI [3.61 , 4.41], la qual cosa indica que la amotivación cap a la AF va ser un moderador de l'efecte de la condició sobre l'excitació, representant el 11.26% de la variància. Les anàlisis de pendents simples van mostrar que hi havia una relació positiva entre la condició i l'excitació quan la amotivación era "més baixa", b = -0,81, 95% CI [-1.77, 0.15], t = -1,72, p = .097. No obstant això, no va aconseguir la significació. A més, les anàlisis de moderació van mostrar que la motivació intrínseca cap a la tasca de AF moderava el canvi de

velocitat. Quant a la motivació intrínseca cap a la AF, el model general va explicar el 42.59% de la variació, $F(3,26) = 3.06$, $p = .046$. La interacció entre la condició i la motivació intrínseca no va incloure el valor zero en l'interval de confiança, $F(1,26) = 5.09$, $p = .032$, 95% CI [15.48, 19.05], indicant que la motivació intrínseca cap a la AF va ser un moderador de l'efecte de la condició en la velocitat, representant el 14.16% de la variància. Les anàlisis dels pendents simples van mostrar que hi havia una relació positiva significativa entre la condició i la velocitat quan la motivació intrínseca era "més alta", b = -5,03, 95% CI [-10,13, 0,06], $t = -2,03$, $p = .052$.

Per tant, aquest estudi suggereix que els entorns de RV són útils per a manipular la retroalimentació rebuda durant una tasca de AF i per consegüent, influenciar sobre variables relacionades amb la seua pràctica com ara l'afecte, l'excitació i la velocitat. D'igual manera, cal ressaltar, que hi ha característiques relacionades amb l'usuari del programa de RV, com ara l'autoeficàcia o la motivació que poden influir sobre els efectes esperats de l'entorn de RV.

3.3. Els efectes de l'aparença física dels avatars en l'activitat física: Provant la teoria cognitiva social, l'efecte Proteus i les prediccions del gradient de meta en la freqüència cardíaca i el comptatge de passos

Aquest estudi experimental es detalla en el capítol 4, i està fonamentat en diverses teories i supòsits sobre la influència dels avatars sobre la pràctica de AF. D'una banda, la literatura ha mostrat que, en congruència amb la teoria cognitiva social, és important que els avatars mostren la cara de l'usuari (Fox & Bailenson, 2009). D'altra banda, diversos estudis suggereixen que l'ús d'avatars amb característiques físiques estereotipades també pot influir en la pràctica de AF (Clark et al., 2019), la qual cosa es troba vinculat al “Efecte Proteus”, que prediu que els individus adapten el seu comportament a la identitat del seu avatar i al que creuen que s'espera de la seua persona virtual (Yee & Bailenson, 2007). Fins hui, pocs estudis han examinat la intersecció entre la teoria cognitiva social i l'Efecte Proteus.

L'objectiu principal d'aquest estudi consisteix a provar les prediccions de la teoria cognitiva social i l'efecte Proteus per a analitzar com l'exposició a avatars controlats per l'usuari que portaven la cara dels participants o d'estranys mentre usaven roba esportiva o roba formal influiria en la pràctica de AF (recompte de passos i freqüència cardíaca). A més, aquest estudi examina la dimensió temporal de les intervencions basades en els avatars amb l'objectiu d'augmentar la pràctica de AF i per a això es basa en la hipòtesi del gradient de meta (Hull, 1932).

La mostra va estar composta per 305 participants d'entre 18 i 37 anys (*M* = 20.02; *DT* = 2.22), amb un IMC mitjà (*M* = 23.21; *DT* = 4.18), i que no tenien cap impediment per a practicar AF. Els participants van ser assignats a l'atzar a la condició de "Cara del participant" o "Cara d'un estrany" i "Roba esportiva" o "Roba formal". A continuació, els participants es van familiaritzar amb un sistema de rastreig de moviment, el qual mostrava una pista de carrera amb el seu avatar en pantalla mentre que una cambra Kinect capturava els seus moviments de braços, cintura i cames. A continuació, van realitzar la prova de Cooper, una tasca de AF que consistia a córrer el més lluny possible durant 12 minuts usant acceleròmetres i un monitor de freqüència cardíaca (GT3X and GT9X). Finalment, quan van acabar de córrer, es va mesurar l'altura i el pes i van contestar el qüestionari d'identificació amb l'avatar (Van Looy et al., 2012).

Es van realitzar ANOVAS per a establir si els participants s'identificaven amb el seu avatar assignat a l'atzar. La freqüència cardíaca dels participants es va dividir en tres fases de quatre minuts (inici, mitjà i final) basades en les 12 mesuraments d'època d'un minut registrades pel monitor de freqüència cardíaca. Es va crear una mitjana de la freqüència cardíaca dels participants per a cadascuna de les tres fases. De manera similar, els recomptes de passos mesurats amb l'acceleròmetre de turmell es van fer una mitjana de en tres fases de quatre minuts (inicial, mitjana i final) basades en les 12 mesuraments d'intervals d'un minut. Per a establir si un efecte de gradient es manifestava en les dades de AF, la freqüència cardíaca i el recompte de passos en les fases inicial, intermèdia i final es van comparar entre si utilitzant

proves t de mostres aparellades. Els resultats van ser analitzats amb ANCOVAs i l'IMC va ser usat com covariable.

Els resultats principals van mostrar que els participants havien augmentat les puntuacions d'identificació quan l'avatar tenia la cara del participant (versus "La cara d'un estrany"), $F(1, 297) = 8.62$, $p = .004$, $\eta^2_p = .028$. Els participants també van mostrar majors puntuacions d'identificació quan se'ls va assignar als avatars vestits d'esport (versus "Avatars amb roba formal"), $F(1, 297) = 11.11$, $p = .001$, parcial $\eta^2_p = .036$. Quant a la freqüència cardíaca, tots els participants van mostrar freqüències cardíaques més altes en la fase final ($M = 150.31$; $DT = 29.59$) en relació amb les fases inicial ($M = 126.84$; $DT = 37.68$) i mitjana ($M = 143.72$; $DT = 30.83$), $t(282) = 10.438$, $p = .001$, d = .621 i $t(290) = 9.010$, $p = .001$, $d = .528$, respectivament. Els participants també van mostrar freqüències cardíaques més altes en la part mitjana en relació amb la fase inicial, $t(282) = 8.198$, $p = .001$, $d = .487$. Quant al nombre de passos, els participants van mostrar un augment de passos en la fase final ($M = 76.71$; $DT = 11.15$) en comparació amb les fases inicial ($M = 74.61$; $DT = 10.02$) i mitjana ($M = 75.59$; $DT = 10.14$), $t(211) = 2.617$, $p = .01$, $d = .180$ i $t(211) = 2.780$, $p = .006$, $d = .191$, respectivament. En general, l'efecte del gradient va estar present de manera de confiança en la freqüència cardíaca i en el nombre de passos de tots els participants.

Encara que no va haver-hi diferències per a la fase inicial Fase inicial $F(1, 274) = .294$, $p = .588$, $\eta^2_p = . 001$, els participants que van ser assignats a l'atzar a avatars amb la cara del propi participant van mostrar un augment de la freqüència cardíaca en les fases mitjana i final de la tasca de AF en relació amb els quals van ser assignats a un avatar amb la cara d'un estrany, Fase mitja $F(1, 274) = 5.371$, $p = .021$, $\eta^2_p = .019$ i fase final $F(1, 274) = 8.225$, $p = .004$, $\eta^2_p = .029$. Quant al recompte de passos, encara que no va haver-hi diferències per a les fases inicial i mitjana, va haver-hi un efecte d'interacció significatiu per als recomptes de passos en la fase final, fase inicial $F(1, 203) = 2.657$, $p = .105$, $\eta^2_p = .013$, fase mitja $F(1, 203) = 2,760$, $p = .098$, $\eta^2_p = .013$, i fase final $F(1, 203) = 3.930$, p = .049, $\eta^2_p = .019$. Entre els participants assignats a l'avatar en roba esportiva, aquells que van veure el seu propi rostre van fer més passos en la fase final

en comparació amb els participants que van veure un avatar amb rostre d'un estrany, $t(102) = 1.664$, $p = .045$, $d = .321$.

Com es pot observar, aquest estudi dona suport a la possibilitat d'utilitzar models d'avatars virtuals per a fomentar la AF secundant-se en mecanismes psicològics coneguts com la teoria cognitiva social, l'efecte Proteus i la hipòtesi del gradient de meta. Una vegada més, es destaca la importància de personalitzar els avatars utilitzats en les intervencions destinades a augmentar la pràctica de la AF.

3.4. Manipulant les dimensions corporals dels avatars en els mons virtuals per a complementar una intervenció en Internet per a augmentar l'activitat física en les dones amb sobrepés

Aquest estudi experimental es desenvolupa en el capítol 5, i part de la base que l'ús d'avatars amb diferents dimensions corporals sembla ajudar els individus a superar les dificultats de representació corporal durant la pràctica de la AF (Petkova, & Ehrsson, 2008; Serino et al., 2016) i, en conseqüència, potenciar la seua pràctica (Song et al., 2014).

L'objectiu principal d'aquest estudi va consistir a analitzar la influència de les dimensions corporals dels avatars sobre l'eficàcia d'una intervenció per Internet per a augmentar els nivells de AF i millorar altres variables relacionades amb la seua pràctica (motivació cap a la AF, gaudi, ansietat, autoeficàcia i establiment d'objectius de AF) en dones amb sobrepés i insatisfacció corporal.

La mostra va estar composta per 42 dones amb sobrepés, amb un IMC mitjà de ($M = 28.7$; $DT = 3.1$), que eren sedentàries i tenien insatisfacció corporal (Qüestionari d'Esquema Corporal -BSQ- >80). Les seues edats oscil·laven entre els 19 i els 61 anys ($M = 31.9$; $DT = 11.7$). Les participants van ser assignades a l'atzar a una de les condicions, “Avatar ideal”, “Avatar real” i condició de “No avatar”.

En primer lloc, tots els participants van rebre un correu electrònic amb l'enllaç per a emplenar els qüestionaris en línia relacionats amb la pràctica de AF (IPAQ; Craig et al., 2003), la motivació (BREQ-2; Markland & Tobin, 2004), autoeficàcia (ESE; Bandura, 2006), gaudi (PACES; Motl et al., 2001), i ansietat (PASAS; Norton et al., 2004). Després, els participants van rebre un enllaç amb la intervenció en línia que havien de realitzar durant una setmana per a augmentar la AF. Després de set dies, els participants van ser convidats individualment al laboratori, on es va aplicar la tasca virtual de AF durant uns 10 minuts. La tasca virtual va variar en les tres condicions.

Als participants de la condició "Avatar ideal" se'ls va demanar que crearen un avatar amb les seues dimensions corporals ideals i el seu propi rostre. A continuació, van fer una tasca de AF, la qual consistia a córrer durant 4 minuts en un escenari de RV on van ser representats per aquest avatar. L'execució de la tasca de RV va ser gravada en vídeo, i els participants van rebre aquest vídeo en els seus telèfons mòbils i se'ls va demanar que el veren tots els dies de la setmana. Els participants de la condició "Avatar real" van rebre les mateixes instruccions, però se'ls va demanar que canviaren l'avatar (amb la seua cara) perquè s'ajustara a les dimensions reals del seu cos. Als participants de la condició "No avatar" se'ls va demanar que feren la tasca de AF en l'escenari de RV durant 4 minuts, però els participants no van ser representats per un avatar. Van córrer enfront d'una imatge fixa corresponent a l'entorn de RV. No van rebre cap enregistrament de vídeo.

Finalment, es va demanar a tots els participants que triaren una meta setmanal de AF (caminar o córrer tres vegades per setmana). Una setmana més tard, van rebre un correu electrònic amb l'enllaç per a respondre els qüestionaris en línia (IPAQ, BREQ-2, ESE, PACES, PASAS i identificació amb l'avatar de Van Looy et al., 2012). Tots els participants van tornar al laboratori per a reportar l'assoliment de les metes de AF i rebre la seua recompensa per completar l'estudi.

Es van realitzar ANOVAs de mesures repetides per a avaluar la influència de les dimensions corporals dels avatars en la AF sobre cada variable (motivació, gaudi, ansietat, autoeficàcia i nivells de AF). A més, es van dur a terme ANOVAs univariados per a analitzar les diferències entre les condicions en el temps emprat en la intervenció, la visualització del vídeo durant la setmana, i l'assoliment de les metes de AF. En segon lloc, per a comprovar les diferències entre les condicions en l'objectiu de AF triat, es va realitzar una prova de chi-quadrat, utilitzant Monte Carlo amb 10.000 mostres com un nivell de confiança del 99%. Finalment, usant el Model 6 del PROCÉS 3.3, realitzem dues anàlisis seriades de mediació múltiple per a provar si els efectes de la condició en el canvi de AF estaven mediats per l'autoeficàcia i la similitud percebuda amb l'avatar.

Els resultats van revelar que tots els participants van mostrar nivells més alts de AF després de la intervenció, $F(1, 39) = 15.82$, $p = .000$, $\eta^2_p = .29$ i també d'autoeficàcia cap a la AF, $F(1, 39) = 8.49$, $p = .006$, $\eta^2_p = .18$). D'igual manera, tots els participants van mostrar nivells d'ansietat més baixos durant la AF després de la intervenció, $F(1, 39) = 18.18$, $p = .000$, $\eta^2_p = .32$. Quant als nivells d'ansietat, la interacció entre el temps i la condició també va ser significativa $F(2, 39) = 4.57$, $p = .016$, $\eta^2_p = .19$. Les comparacions post-hoc usant la correcció de Bonferroni van revelar que els participants de la condició "Avatar ideal" i la condició "No avatar" van mostrar nivells d'ansietat més baixos durant la AF després de la intervenció ($p = .010$ i $p = .000$), comparats amb els participants de la condició "Avatar real".

D'igual manera, és important destacar els canvis observats en la condició del "Avatar real". Segons les grandàries d'efecte estandarditzats (Cohen's d), aquest grup va obtindre una gran grandària d'efecte (>.80) pel seu canvi en els nivells de AF, i va ser el que més va augmentar la seua pràctica setmanal. De manera similar, els resultats també van mostrar: una grandària d'efecte mitjà (<.50) per a la motivació intrínseca per a aquests participants, els qui van augmentar les seues puntuacions de motivació intrínseca més; una grandària d'efecte gran (>.80) per a la motivació externa en els participants de la condició "Avatar ideal", els qui van

augmentar les seues puntuacions de motivació externa més; i una grandària d'efecte gran (>.80) per a les expectatives d'autoeficàcia en els participants en la condició de “No avatar”, els qui van augmentar les seues puntuacions d'expectatives d'autoeficàcia més. Donats aquests resultats, encara que a través d'aquest estudi no es poden concloure diferències significatives entre els grups, seria interessant augmentar el poder estadístic de l'estudi.

Aquest estudi suggereix que la intervenció en línia utilitzada en aquest estudi va ser eficaç per a augmentar la pràctica de la AF i les expectatives d'autoeficàcia en les dones amb sobrepés i insatisfacció corporal. La manipulació de les dimensions corporals dels avatars no va millorar aquesta intervenció. L'ús d'avatars ideals sembla reduir l'ansietat experimentada durant la AF en aquesta població. No obstant això, l'ús d'avatars similars a la persona mateixa podria tindre un major impacte en la AF i les variables relacionades amb la seua pràctica a llarg termini.

4. Conclusions i discussió

Tal com s'ha exposat al llarg de la tesi doctoral, promoure la pràctica de AF entre la població és un objectiu prioritari de salut pública. La RV ha demostrat ser una eina útil per a promoure comportaments saludables. No obstant això, amb la finalitat d'obtindre conclusions més fermes sobre això, són necessaris més estudis que analizen la influència que tenen els entorns virtuals i les representacions virtuals dels usuaris sobre la pràctica de AF i variables tant físiques com psicològiques relacionades amb la seua pràctica. La present tesi doctoral va sorgir de la necessitat d'ampliar aquest camp d'estudi.

Per a això, s'han dut a terme quatre estudis, un psicomètric i correlacional i tres experimentals. En els següents paràgrafs s'exposaran les conclusions, responent a cadascun dels objectius generals de la tesi:

1) *Validar les propietats psicomètriques d'un instrument destinat a avaluar els diferents nivells de motivació cap a la AF en la població adolescent espanyola, així com analitzar les diferències de motivació segons el sexe i l'edat; i el paper de l'edat i el sexe en la*

relació entre la motivació i el gaudi de la AF. Els resultats d'estudi 1 confirmen l'existència d'una estructura de cinc factors en el qüestionari sobre la regulació del comportament en l'exercici (BREQ-2) en la població adolescent espanyola. No obstant això, també ha sorgit una estructura de quatre factors amb una única regulació intrínsecament identificada amb un ajust adequat. D'igual manera, aquest estudi ha demostrat que els diferents tipus de regulació de la AF fluctuen en funció de l'edat i el sexe. A més, aquest estudi mostra que els tipus de regulació més autodeterminados s'associen positivament amb construccions psicològiques relacionades amb la pràctica de la AF. Finalment, aquest estudi destaca la importància de fomentar tipus específics de regulació del comportament per a augmentar el gaudi en funció de l'edat amb la finalitat de desenvolupar intervencions de AF.

2) *Analitzar la influència de l'ús de la RV per a influir en la pràctica de la AF i les variables físiques i psicològiques relacionades amb la seua pràctica.* La resposta a aquest objectiu va ser atorgada per l'estudi 2, els resultats del qual mostren que els entorns de RV són útils per a manipular la retroalimentació rebuda durant una tasca de AF i per consegüent, influenciar sobre variables relacionades amb la seua pràctica com ara l'afecte, l'excitació i la velocitat. D'igual manera, aquest estudi ressalta que hi ha certes característiques relacionades amb l'usuari del programa de RV, com ara l'autoeficàcia o la motivació que poden influir sobre els efectes esperats de l'entorn de RV.

3) *Investigar la influència de l'aparença física de l'avatar en la pràctica de la AF i les variables físiques i psicològiques relacionades amb la pràctica.* Els resultats de l'estudi 3, donen suport a la possibilitat d'utilitzar models d'avatars virtuals per a fomentar la AF secundant-se en mecanismes psicològics coneguts com la teoria cognitiva social, l'efecte Proteus i la hipòtesi del gradient de meta. Aquest estudi ressalta una vegada més la importància de personalitzar els avatars utilitzats en les intervencions destinades a augmentar la pràctica de la AF (per exemple, cara i roba de l'avatar).

4) *Investigar l'efectivitat de l'ús dels avatars per a complementar les intervencions en línia existents per a millorar la pràctica de AF*. Els resultats de l'estudi 4 suggereixen que la intervenció en línia utilitzada en aquest estudi és eficaç per a augmentar la pràctica de la AF i les expectatives d'autoeficàcia en les dones amb sobrepés i insatisfacció corporal. A més, la manipulació de les dimensions corporals dels avatars no millora aquesta intervenció. L'ús d'avatars ideals sembla reduir l'ansietat experimentada durant la AF en aquesta població. No obstant això, l'ús d'avatars similars a l'usuari podria tindre un major impacte en la AF i les variables relacionades amb la seua pràctica a llarg termini.

La present tesi doctoral té diverses fortaleses que atorguen solidesa als principals resultats. Aquestes fortaleses són: (1) s'estudia un tema molt nou en la psicologia experimental, clínica i de la salut sobre el qual hi ha pocs estudis i moltes qüestions per resoldre; (2) s'analitza l'impacte de la RV en la AF en diferents poblacions (xiquets, adults, població general i població clínica com les dones amb sobrepés); (3) desenvolupa nous entorns de RV; (4) inclou variables relacionades amb l'aparença física de l'avatar que mai han sigut incloses en estudis anteriors, com la roba de l'avatar i la seua influència en la pràctica de la AF; (5) analitza si l'ús dels avatars i les seues variacions físiques poden millorar l'eficàcia d'intervencions existents per a augmentar el nivell de AF; (6) examina la intersecció entre dues teories que intenten explicar la influència dels avatars en la pràctica de AF, la teoria cognitiva social i l'efecte Proteus; (7) inclou acceleròmetres i monitors de freqüència cardíaca per a mesurar amb major precisió la influència dels avatars en la pràctica de AF; i (8) inclou contribucions d'universitats internacionals, la Universitat de Davis, Califòrnia.

No obstant això, la present tesi doctoral no està exempta de limitacions. Les limitacions que són comunes a tots els estudis són: (1) Els sistemes de RV utilitzats són semiinmersivos i no sempre s'ha mesurat la immersió de l'individu a l'entorn de la RV; (2) encara que es va calcular la grandària mínima de la mostra necessària per a tots els estudis, no sempre s'ha complit; (3)

no s'inclouen mesures de seguiment en cap dels estudis; i (4) no s'inclou un grup de control en tots els seus estudis.

Com a futures direccions, a més d'esmenar les limitacions anteriors, seria recomanable: (1) utilitzar entorns de RV més immersius i incloure sempre aquesta mesura en el protocol de l'estudi; (2) incloure característiques dels individus, com les seues característiques físiques, les seues aptituds, la seua experiència en entorns de RV i les seues característiques psicològiques com a variables moderadores; (3) replicar alguns dels estudis de tesis amb grandàries de mostra més grans i mostres diferents; (4) fins hui el "vertader" jo s'ha comparat principalment amb el "jo" ideal. No obstant això, la literatura mostra que el "futur" jo pot ser un camp prometedor en el context dels comportaments saludables entre els quals es troba la pràctica de la AF; i (5) incloure dispositius tecnològics per a mesurar el moviment dels ulls de l'individu (per exemple, el rastreig ocular) mentre interactua amb l'entorn de RV.

En conclusió, la present tesi doctoral proporciona evidències que el qüestionari BREQ-2 és una eina útil per a mesurar la motivació cap a la AF en la població adolescent espanyola. A més, es confirma una vegada més que la motivació cap a la AF és una variable a tindre en compte per a entendre el comportament de la AF degut, entre altres coses, a la seua relació amb altres variables que també prediuen aquest comportament. En relacion a l'aplicació de la RV a la pràctica de AF, els resultats assenyalen que els ambients de RV són efectius per a manipular la retroalimentació rebuda durant una tasca de AF i, conseqüentment, influenciar en les respostes físiques i psicològiques de la AF (per exemple, l'afecte, l'excitació i la velocitat). D'igual manera, es conclou, que els models d'avatars virtuals poden encoratjar la pràctica de AF confiant en mecanismes psicològics coneguts com la teoria cognitiva social, l'efecte Proteus i la hipòtesi del gradient de meta. La breu intervenció en línia utilitzada en aquesta tesi va ser eficaç per a augmentar la pràctica de AF i les expectatives d'autoeficàcia en dones amb sobrepés i insatisfacció corporal. No obstant això, en aquest cas, l'ús d'avatars i la manipulació de les dimensions corporals d'aquests no han millorat la intervencion. Pel que sembla, l'ús d'avatars

ideals pot reduir l'ansietat experimentada durant la AF en aquesta població. No obstant això, l'ús d'avatars similars als de les persones pot tindre un major impacte en la AF i les variables relacionades en la pràctica a llarg termini.

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INTRODUCTION

There is growing evidence to support the health benefits of physical activity (PA), so being physically active is a common message in any health promotion campaign (Warburton & Bredin, 2016).

In order to achieve such benefits, the WHO proposes a series of recommendations at the global level, according to the age of individuals (WHO, 2010). Despite the benefits that PA practice provides to individuals, a large part of the population still does not meet the recommended minimums. In fact, Spain is the eighth country in the European Union as a whole and the fifth country in Europe in which the largest percentage of the population does not meet the minimum recommendations of the WHO (Mayo, 2017). For this reason, it is considered necessary to continue developing interventions aimed at promoting PA practice among the population.

The literature shows that there are multiple barriers to be overcome if PA practice is to be promoted and these barriers vary according to some characteristics of individuals, such as age, sex and the individual's own weight. The perception of barriers to PA can be understood as a set of intra- and interpersonal factors that significantly predict adherence to PA practice (Bauman et al., 2012). Internal barriers refer to aspects such as lack of confidence in one's own abilities, feelings of discomfort during PA, lack of motivation, preference for other skills, lack of knowledge about the benefits of PA and self-awareness about the body and physical appearance. Interpersonal barriers refer to the influence that the individual's context (e.g., school, family and friends) can have on PA practice and the existence of practical and material resources such as time and money.

In order to promote PA and develop effective interventions aimed at increasing its practice among the population, there are different models and theories that have already proven their effectiveness and that have helped to understand the variables and mechanisms that favor overcoming of the above barriers, which have been shown to influence adherence to

PA practice. Among these models are the cognitive social theory (Bandura, 1986), the theory of self-determination (Decy & Ryan, 1985), the trans-theoretical model (Prochasca & DiClemente, 1983), the theory of reasoned action (Fishbein & Ajzen, 1975) and the social ecological model (Brofenbrenner, 1976). Many of the interventions that have been based on these models and theories have shown their effectiveness mainly in the short term. In addition, there are some barriers that through the use of these theories and models, can be understood, but cannot be easily addressed.

In this context, virtual reality (VR) makes it possible to influence the variables and mechanisms present in the above-mentioned models, which seek to promote PA. Similarly, VR allows us to overcome internal and external barriers in the PA practice that cannot be influenced by traditional methods. The use of VR is already considered a new method for promoting healthy behaviours, including the practice of PA (Ahn & Fox, 2017). VR applied to sport can be defined as where people play a sport represented in a computer simulated environment that is intended to induce a sense of mental or physical presence and allows for interactivity with the virtual environment (Alhadad & Abood, 2018).

The application of VR to sport has several strengths (Alhadad & Abood, 2018). On the one hand, VR allows for control and manipulation, so it can be useful in physically training individuals. VR can be used to perform assessments, obtain performance information and practice specific skills. Sports activities that are dangerous or expensive for individuals can be carried out through VR programs. In addition, VR is not always individual, but allows for the inclusion of other individuals who are physically located elsewhere. Similarly, no specialist technical knowledge is required for its use, so VR programs can be used in both gyms and at home (Hoffman et al., 2014). Another advantage of this technology is that it allows to overcome possible negative environmental influences such as climate (Plante et al., 2003).

VR can be a useful means of changing attitudes and behaviours in health care settings, including the practice of PA. VR allows for greater interactivity, and enables the presentation of

content in a multi-modal way, creating more compelling and engaging experiences for the user. Similarly, VR enables greater accessibility to the public and is an intuitive technology. In addition, VR is considered an entertainment technology and one of the factors driving attitudinal and/or behavioural change is linked to user motivation (Chow et al., 2017). Finally, several studies cited in this thesis show how VR can influence motivation towards PA, self-efficacy, enjoyment during practice and perception of effort.

That VR is a useful method for promoting PA practice is a consistent statement in the literature. However, the study of the influence of the inhabitants of VR environments (agents and avatars) on this effect is currently being promoted. Research show that observation and interaction with these virtual representations allows individuals to immerse themselves in the virtual world and come to feel that they are actually present in the situation (Fox et al., 2009), and increases self-efficacy in achieving health goals (Ahn et al., 2015). In addition, healthy behaviours driven by these representations persist longer than the same information provided by other, more traditional channels (Fox, & Bailenson, 2009). The literature shows that the use of avatars increases PA levels, as they influence the perception of activity, making it more enjoyable, increasing autonomy and competition (Thompson et al., 2018).

During the last years it has been highlighted that the physical appearance of the avatar is a variable to consider (Clark et al, 2019; Peña et al., 2020), and that it can influence in the efficacy of VR environments. In this context, there are currently two major areas of study. On the one hand, there are studies that analyze the role of avatar personalization according to the characteristics of the users. On the other hand, other studies analyze characteristics of the physical appearance of the avatar related to stereotypes. So far, the literature has shown, that according to social cognitive theory (Bandura, 1986), in general, participants who personalize their avatars show a greater intention of behavioral changes (Clark et al., 2019; Peña et al., 2020). Similarly, embodying avatars with certain stereotypical physical characteristics such as avatar body dimensions seems to influence PA practice. The latter effect would be explained by

the "Proteus Effect", which predicts that individuals adapt their behavior to the identity of their avatar and to what they believe is expected of their virtual person (Yee & Bailenson, 2007). Although there are studies on the effect that the physical appearance of the avatar has on PA practice, studies are still too limited to make firm conclusions about it. Currently, there is a need to continue this line of research in order to draw firm conclusions as well as clear explanatory variables for these found effects.

Hence, this dissertation has several general objectives. Firstly, our interest was focused on the analysis of motivation towards PA practice in adolescents. To do so, we validated the BREQ-2 questionnaire in the Spanish adolescent population and analyzed the role of motivation in PA practice in this population. Secondly, our objectives focused on analyzing the influence of VR environments and virtual representations of users on PA practice and specific interventions designed to promote this behavior. To do so, a review of scientific literature to stablish the state of the topic is carried out in chapter 1. Subsequently, chapters 2, 3, 4 and 5 present the four studies in "article format", because they have been submiteed to scientific journals indexed in the Journal Citation Report (JCR) of the Web of Knowledge (WOK) platform. Two of them have already been published, and the other two are currently under review. Each chapter includes the abstract, theoretical justification, specific objectives and hypotheses, methodology, results and discussion of each study.

Study 1- entiled *"Adolescent motivation toward physical exercise: the role of sex, age, enjoyment, and anxiety"* is aimed at validate the psychometric structure of the *Behavioural Regulation in Exercise Questionnaire- 2* (BREQ-2) to confirm the existence of five levels of motivation toward PA in Spanish adolescent population; as well as to analyse the differences in motivation according to sex and age; and the role of age and sex in the relationship between motivation and enjoyment.

Study 2- entiled *"The influence of success or failure in the practice of physical activity in children: Manipulating the outcome in a virtual reality task"-,* and Study 3- entiled *"The effects*

of avatar appearance on physical activity: Testing social cognitive theory, proteus effects and goal-gradient predictions on cardiac frequency and step counts"- are aimed at analyzing the influence of manipulating different aspects of the VR environment during a PA task (feedback and physical appearance of the avatar) on PA variable.

Study 4- entiled *"Manipulating self-avatar body dimensions in virtual worlds to complement an Internet-delivered intervention to increase physical activity in overweight women"*-, is aimed at to investigate the use of avatars and their physical variations to extend the effectiveness of existing interventions to promote PA.

Finally, chapter 6 presents the general discussion, which summarizes the main conclusiones of the four studies to provide an answer to the general objectives of this dissertation, as well as describing the limitations and future directions.

From my point of view, this dissertation sheds light on a novel field that has great potential. Therefore, I believe that research in this field is very much needed to determine how specifically VR can help promote the PA practice in different populations and what aspects of VR environments need to be further studied.

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CHAPTER 1. Background

1. Physical activity

1.1. Conceptualization of physical activity and other related terms

Physical activity (PA) can be defined as any bodily movement produced by skeletal muscles that requires an expenditure of energy (Thivel et al., 2018). PA should not be confused with exercise or sport. Exercise consists of a variety of PA that is planned, structured, repetitive and performed with a goal related to the improvement or maintenance of one or more fitness components (Caspersen et al., 1985). PA includes exercise, but also other activities that involve body movement and are performed as part of play, work, and active forms of transportation, household chores, and recreational activities. Sport is part of the PA spectrum and corresponds to any institutionalized and organized practice, based on specific rules. Some very active individuals might not be sport athletes even though they regularly train and show a high level of PA (Thivel et al., 2018).

1.2. Benefits derived from physical activity practice

PA provides enormous benefits to the physical and mental well-being of individuals, even with reduced levels of PA (Mayo et al., 2017). According to the World Health Organization (WHO) (2010), the practice of PA reduces the risk of hypertension, coronary heart disease, stroke, diabetes, breast and colon cancer, depression and falls. It also improves bone and functional health and is essential for caloric balance and weight control. Similarly, a recent review replicated that there is strong evidence that regular PA is associated with a lower risk of all-cause mortality and several chronic diseases (including cardiovascular disease, type 2 diabetes, hypertension, breast cancer, colon cancer, gestational diabetes, gallstone disease, ischemic heart disease, and ischemic stroke) (Warburton & Bredin, 2017).

In addition to physical health benefits, the PA practice is increasingly linked to improved well-being and mental health (Lee & Russell, 2003). In general, people who have become physically active within 3 years showed positive changes in emotional well-being, while the

opposite occurs when they become less active (Lee & Russell, 2003). Such findings have been replicated with adults (Reijneveld et al., 2003) and children (Calfas et al., 1991). The relationship between lack of regular PA and mental disorders has been also studied (Babyak et al., 2000; Dunn et al., 2001; Mather et al., 2002; Mutrie, 2002; Goodwin, 2003). Specifically, studies have shown that individuals who regularly practice PA were less likely to meet the diagnostic criteria for major depression (8% vs. 13%) and a range of anxiety disorders (agoraphobia: 3% vs. 5%; social phobia: 7% vs. 11%; specific phobia: 7% vs. 11%; generalized anxiety disorder: 2% vs. 4%; and panic attacks: 3% vs. 6%) (Goodwin, 2003).

1.3. Recommendations for physical activity practice

In order to achieve the above-mentioned health benefits, the WHO, (2010), proposes global recommendations:

Young people (5 to 17 years old)

For children and young people in this age group, PA consists of games, sports, travel, recreation, physical education or scheduled exercise, in the context of family, school or community activities. In order to improve cardiorespiratory and muscular functions and bone health and to reduce the risk of noncommunicable diseases, it is recommended that:

- Children and young people aged 5-17 years invest at least 60 minutes per day in moderate to vigorous PA.
- PA for more than 60 minutes per day will provide even greater health benefit.
- Daily PA should be mostly aerobic. Vigorous activity that strengthens muscles and bones in particular should be incorporated at least three times a week.

Adults (18 to 64 years old)

For adults in this age group, PA consists of recreational or leisure activities, travel (e.g. walking or cycling), occupational activities (i.e. work), household chores, games, sports or scheduled exercises in the context of daily, family and community activities. In order to improve

cardiorespiratory and muscular functions and bone health and to reduce the risk of noncommunicable diseases and depression, it is recommended that:

- Adults 18-64 years old engage in at least 150 minutes per week of moderate-intensity aerobic PA or 75 minutes of vigorous aerobic PA each week, or an equivalent combination of moderate and vigorous activities.
- Aerobic activity shall be performed in sessions of at least 10 minutes.
- That, in order to obtain even greater health benefits, adults in this age group increase to 300 minutes per week of moderate aerobic PA, or up to 150 minutes per week of vigorous aerobic PA, or an equivalent combination of moderate and vigorous activity.
- Twice or more per week, engage in large muscle group strengthening activities.

Older adults (65 years and older)

For adults in this age group, PA consists of recreational or leisure activities, travel (for example, walking or cycling), occupational activities (when the person is still working), household chores, games, sports or scheduled exercises in the context of daily, family and community activities. In order to improve cardiorespiratory and muscular functions and bone and functional health, to reduce the risk of noncommunicable diseases, depression and cognitive impairment, it is recommended that:

- Adults 65 and older should engage in 150 minutes per week of moderate aerobic PA, or some form of aerobic vigorous PA for 75 minutes, or an equivalent combination of moderate and vigorous activity.
- The activity should be done in sessions of at least 10 minutes.
- For greater health benefits, adults in this age group should engage in up to 300 minutes per week of moderate aerobic PA, or 150 minutes per week of

vigorous aerobic PA, or an equivalent combination of moderate and vigorous activity.

- Adults in this age group with reduced mobility should engage in PA to improve their balance and prevent falls, three days or more per week.
- Activities that strengthen the major muscle groups should be done two or more days a week.
- When older adults are unable to do the recommended PA because of their health, they will stay physically active as long as their condition allows.

Although the international recommendations for PA discussed above have traditionally been followed, a recent review by Warburton & Bredin (2017) revealed non-linear relationships between PA and health outcomes, such that the greatest benefits are seen at lower doses of PA (e.g., when moving from an inactive state to a more active state). The literature shows that multiple dose-response curves may exist and that optimal and minimum doses are likely to vary depending on the primary outcome (Warburton & Bredin, 2016). The optimal and minimum volume of PA required to obtain health benefits has not yet been determined. It is clear that participation in PA at levels consistent with international recommendations can lead to health benefits and a reduced risk of premature mortality and at least 25 chronic medical conditions (Warburton et al., 2010). However, there is increasing evidence that this volume of activity is not the minimum level required for health benefits and may even be closer to the optimal level (depending on the medical outcome) (Warburton & Bredin, 2016). Moore et al. (2012) reported that any volume of PA led to 1.8 years of increased life, which translated into additional benefits at higher levels of PA. Arem et al. (2015) also recently found that any level of participation in PA resulted in a 20% reduction in mortality risk, while compliance with current recommendations had a 31% mortality benefit. Therefore, caution should be exercised when recommending a specific amount of PA for various populations, particularly for inactive individuals and/or those

living with chronic medical conditions who would benefit greatly from becoming more physically active.

1.4. Physical inactivity and sedentariness

Despite the enormous benefits of meeting the above-mentioned minimum recommendations, physical inactivity (PI) and sedentary lifestyles continue to be serious public health problems (WHO, 2010).

Although PI and sedentariness are related terms, should be considered as independent constructs (Biddle et al., 2004). While PI refers to non-compliance with global health recommendations, sedentary life refers to all those activities that require low energy expenditure, such as watching TV and using the computer, the fundamental characteristic of this type of behavior being predominantly seated (Thivel et al.,2018). In terms of energy expenditure, sedentariness represents a slight increase in energy expenditure above the basal metabolic rate, but below the energy expenditure observed with a light intensity PA (Pate et al., 2008).

1.5. Inactivity and sedentarism as a global health problem

According to the WHO (2010), PI and sedentarism are a global pandemic that has become one of the leading causes of death in the world. In fact, it constitutes the fourth most important risk factor for mortality (WHO, 2010). The literature shows that PI is associated with increased abdominal and visceral fat (Slentz et al., 2005), and with a higher risk of type 2 diabetes (Admiraal et al., 2011; Knight 2012), cancer, heart disease, stroke and shortens lifespan by 3–5 years (Wen et al., 2011; Lee et al., 2012). In short, this is one of the main risk factors for non-communicable diseases (Wen & Wu, 2012). PI is one of the most important premature death risk factors, already outperforming tobacco consumption and only behind the hypertension and excess blood glucose (Lee et al., 2012). Accumulated evidence shows that, regardless of the

levels of PA reached, sedentary lifestyle is associated with an increase in cardiovascular disease, a variety of physiological and psychological problems and in general with many causes of mortality (Tremblay et al., 2010). In addition, according to the literature, it is estimated that in developed countries PI is responsible for 1.5-3% of total direct health care costs for the treatment of chronic diseases (Oldridge, 2008). Ding et al. (2016) showed that in 2013, the total cost of PI worldwide reached $61.7 billion.

Spain is the 8th country in the European Union as a whole and the fifth country in Europe where the highest percentage of the population does not comply with WHO recommendations. PI is responsible for 13.4% of deaths in Spain each year, claiming more than 52.000 lives. This represents a significant economic burden for the country of more than 1,560 million euros, 70.5% of which is paid for by the public administrations. With a 10% reduction in downtime levels, in other words, by complying with the WHO's voluntary strategic objectives for 2025, the minimum estimated savings for Spain would reach 156 million euros per year (Mayo et al., 2017).

1.6. Physical Inactivity and sedentarism in the population

The literature shows that the population is not physically active enough. Several studies cited in this dissertation analyze the prevalence of PI in different population groups, such as children and adolescents, adults, and specific populations such as overweight or obese individuals. The results of these studies outlined below highlight the need to develop interventions aimed at promoting PA practice.

Children and adolescents

Globally, in 2016, 81.0% of students aged 11-17 years were not sufficiently physically active (77. 6% of boys and 84.7% of girls). Although the prevalence of insufficient PA decreased significantly between 2001 and 2016 for boys, there was no significant change for girls. Regarding the country's income group, the prevalence of insufficient PA in 2016 was 84.9% in

low-income countries, 79.3% in lower-middle-income countries, 83.9% in upper-middle-income countries, and 79.4% in high-income countries (Guthold et al., 2020).

Regarding the rates of PI and sedentary behaviour in the Spanish child and adolescent population, the 2016 report on PA in children and adolescents in Spain (Román et al., 2017) collected data on overall PA, participation in organized sport, active play outside school, active transport, and sedentary behaviour. This study shows that less than half of Spanish children and adolescents complied with the recommendations on daily PA, that is, accumulating 60 minutes of moderate and/or vigorous PA throughout the day, taking into account travel, class of PA, school breaks, PA in free time, etc. On the other hand, more than half of the children and teenagers did sport outside school hours, at least once a week. Regarding active play, about half of the children and adolescents spent about 2 hours a day playing outdoors. Finally, about half were active on the go. The recommendation for children and young people indicates that they should spend less than 2 hours a day doing sedentary activities (e.g., watching TV, playing with video consoles, using the computer, mobile phone, etc.) and for children under 5 years of age, the recommendation is reduced to 1 hour a day. The results showed that less than half of the children and adolescents complied with this recommendation. In short, less than half comply with the recommendations of PA and sedentarism (Román et al., 2017).

Adults

Globally, more than a quarter of adults were insufficiently physically active in 2016 (Guthold et al., 2018). Prevalence of insufficient PA varied greatly across regions and income groups in 2016. Prevalence in 2016 was more than double in high-income countries (36.8%) than in low-income countries (16.2%), and under-activity has increased in high-income countries over time.

According to the latest report on PI and sedentary life in the Spanish adult population (Mayo et al., 2017), 3 out of 5 adults did not engage in any moderate PA in the last seven days prior to the completion of the same survey. This rate rises to 2 out of 3 Spaniards for vigorous

PA. In comparison with the European Union, our values of PA are high for both moderate and vigorous activities. Spain is the eighth country in the European Union in which the highest percentage of the adult population does not comply with WHO recommendations.

Based on the National Surveys (1993-2011/2012) and the latest European Health Survey of 2014, one in three Spaniards declares that they are "sitting down most of the day" as a fundamental activity of the day, whether it be studying, work, etc. (Mayo et al., 2017). These rates have continued to grow in recent years, with an estimate that this percentage will continue to grow in the future, from 36% of the population observed in the 2014 European Survey, to approximately 38.2% of the population at the end of 2025 (Mayo et al., 2017).

In addition, women used to be more inactive in their free time compared to men and their sports practice is also lower compared to men (Guthold et al., 2018). In addition, their sports culture, interests, perceptions and barriers to PA are also different. Specifically, in the Spanish population, women are still systematically more PI compared to men (Mayo et al., 2017). From the age of 45, the gender gap narrows because of a high prevalence of PI in both genders. Especially notable are the high values of inactivity in the female group in the early age groups, particularly in the 15-34 year interval. However, this difference is being reduced by a gradual reduction in the percentage of women who are completely inactive.

Obese and overweigh people

Traditionally, it is known that obese individuals are generally less active and spend less energy on PA than non-obese subjects (Ferraro et al., 1991; Rising et al., 1994). Cooper et al. (2000) corroborated this information and showed that in work activity, such differences were not significant, although non-obese individuals used their breaks to be more active, while the obese generally did not. Similarly, during evenings and weekends, obese individuals were also significantly less active than non-obese individuals. From these results, it can be concluded that obese individuals, when not dependent on work demands, are less likely to use their free time actively. Finally, in relation to the data provided by accelerometers, the results revealed that 1

fifth of the non-obese individuals and 2 fifths of the obese individuals did not comply with the WHO recommendations (Cooper et al., 2000).

1.7. Barriers and facilitators of physical activity practice

In order to reduce PI in the population, it is crucial to analyze what are the barriers and facilitators in the PA practice.

The perception of barriers to PA can be understood as a set of intra- and interpersonal factors that significantly predict adherence to PA practice (Moore et al., 2010; Bauman et al., 2012). Internal barriers refer to individuals' personal motivations. However, external barriers refer to other aspects such as community infrastructure (Pan et al., 2009; Lovell et al., 2010). The literature shows that PA is inversely related to the perception of personal and environmental barriers, and this association varies according to the characteristics of individuals and gender (Reichert et al., 2007; Cerin et al., 2010). For these reasons, it is considered necessary to analyze the barriers that make it difficult to adhere to PA in the different population groups mentioned above, such as children and adolescents, adults, and more specific populations such as overweight or obese individuals.

Children and adolescents

Hesketh et al. (2017) studied barriers and facilitators to PA and sedentary behaviour in young children aged 0-6. To do this, they conducted a systematic review and synthesis of the qualitative literature. The results showed that according to the literature, PA and sedentary behavior at these ages could be associated with certain predisposition of the child and personal preferences, having rest and inactivity, their level of development, their health, the role that parents acquire in this topic as well as siblings and closest companions, the environment where the child develops, the safety of the child and the climate of the city where they live. Although all of these variables are important, interpersonal barriers and facilitators (e.g., parents,

caregivers, and family) were most often cited, reflecting the important role that adults and peers play in shaping behaviors related to young children's PA practice.

Other authors such as Rees et al. (2006) conducted a systematic review to study the barriers to PA practice presented by children aged 11-16. Some of these barriers are in line with the results found in younger populations such as interpersonal barriers and facilitators (e.g., school, family and friends) and the existence of practical and material resources such as time and economic resources. However, these authors found the relevance of one type of additional barrier related to the self (e.g., lack of confidence in one's own abilities, feelings of discomfort during PA, lack of motivation, preference for other skills, lack of knowledge about the benefits of PA and self-awareness about the body and physical appearance).

In relation to the adolescent population between 13 and 18 years old, another systematic review carried out by Martins et al. (2015), concluded that different variables were considered as barriers to the practice of PA at this developmental stage. Such barriers were a poor attitude towards PA, lack of motivation, lack of enjoyment, low perception of competence, concerns about body image, perception of femininity and social norms incompatible with PA practice, lack of time, negative social influences (e.g. from family, friends or teachers), lack of opportunities related to the place where they take place (e.g. infrastructure, transport or security) and life periods associated with changes (e.g. change from primary school to high school or from high school to the world of work).

Adults

The main variables that have been considered as barriers to PA practice in the adult population have mainly been lack of motivation, the lack of time (Cerin et al., 2010; Justine et al., 2013; Herazo-Beltran et al., 2017; Hoare et al., 2017), the lack of social support in the PA practice (Justine et al., 2013; Herazo-Beltrán et al., 2017; Hoare et al., 2017), health problems, lack of energy, or fear of injury (Cerin et al., 2010; Moschny et al., 2011; Herazo-Beltran et al, 2017; Schoeny et al., 2017), lack of skills (Justine et al., 2013; Herazo-Beltran et al., 2017; Hoare

et al., 2017), lack of enjoyment (Hoare et al., 2017), and lack of resources (Cerin et al., 2010; Moschny et al., 2011; Justine et al., 2013; Herazo-Beltran et al, 2017; Schoeny et al., 2017). It is important to note that as age increases, the health-related barrier becomes heavier and the time-related barrier decreases (Moschny et al., 2011).

In general, barriers to PA are common to both genders. Women also report barriers related to time, lack of resources or skills, social support, climate (Sit et al., 2008; Welch et al., 2009; Heesch et al, 2000), health and motivation (Juarbe et al., 2002). However, there is one barrier that appears more frequently among the female population, concern about body image. Women experience greater self-awareness of their physical appearance during PA practice (Robbins et al., 2003). The literature has shown that this increased self-awareness makes them less likely to participate in PA (Slater & Tiggemann, 2011).

Body image has been defined as the subjective concept of physical appearance and can be positive or negative (Forrest et al., 2007). The perception of physical appearance as positive or negative predicts motivation toward PA (Ingledew & Sullivan, 2001; Russell & Cox, 2003). In this context, body image can act as a barrier to exercise (Focht & Hausenblas, 2004; Schuler et al., 2004). One of the reasons for this is that negative body image can include physical social anxiety, which is the experience of anxiety in the presence of an actual or imagined negative physical assessment (Lanz et al., 1997). People with high levels of physical social anxiety are less likely to put themselves in situations where their bodies can be negatively assessed (Lanz et al., 1997). Thus, those who have a more negative body image and experience greater anxiety are less likely to exercise.

Finally, in the older adult population, the higher prevalence of co-morbidities, pain, fatigue, fear of falls and injuries, discomfort and feelings of insecurity explains the difficulty that obese older people have in engaging in PA (Sallinen et al., 2009).

Overweight and obese people

In relation to the adult population with overweight and obesity, the literature shows the existence of internal barriers to the individual such as overweight (Hulens et al., 2001; Egan et al, 2013; McIntosh et al., 2016), health problems or injuries related to physical condition (Bigal et al., 2007; McIntosh et al., 2016), negative weight perception (Ball et al., 2000; Atlantis & Ball, 2008; Chen et al., 2010; Napolitano et al., 2011; McIntosh et al., 2016), low mood (McIntosh et al., 2016), lack of enjoyment during PA practice (Napolitano et al., 2011; Piana et al., 2013; Peacock et al., 2014; McIntosh et al., 2016), and lack of motivation (Puhl & Heuer, 2009; Napolitano et al., 2011; McIntosh et al., 2016). As for external barriers, these coincide with the barriers found in normal populations (McIntosh et al., 2016) such as lack of time (Napolitano et al., 2011; Bond et al., 2013; Egan et al., 2013; Peacock et al., 2014), lack of knowledge (Wiklund et al., 2011), or related to climate (Napolitano et al., 2011; Bond et al., 2013).

As for the negative perception of one's own weight, this is a specific barrier for this group of the population and must be considered, both for men and women. Napolitano et al. (2011) found that the "feeling of overweight" was often reported by obese individuals as a barrier to PA. Similarly, Ball et al. (2000) and Atlantis et al. (2008) showed that it was the perception of overweight, rather than the actual weight status, that constituted a major barrier to participation for many obese individuals. This barrier may be related to the stigma and stereotypes often directed at obese individuals, both in society at large (Bell, 2005; Lewis & Van Puymbroeck, 2008) and by health professionals (Teachman & Brownell, 2001; Poon & Tarrant, 2009). In this context, other studies have linked the stigma of weight to low self-esteem (Lewis & Van Puymbroeck, 2008; Gatineau & Dent, 2011) which may explain the high prevalence of negative self-awareness as a barrier in this population (Thomas et al, 2008; Groven & Engelsrud, 2010; Wiklund et al., 2011; Piana et al., 2013).

2. Models that can help to understand adherence to physical activity practice

In order to promote PA and develop effective interventions aimed at increasing its practice among the population, there are different models and theories that have already proven their effectiveness and that have helped to understand the variables and mechanisms that favor overcoming of the above barriers, which have been shown to influence adherence to PA practice. Among these models, the cognitive social theory (Bandura, 1986), the theory of self-determination (Decy & Ryan, 1985), the trans-theoretical model (Prochasca & DiClemente, 1983), the theory of reasoned action (Fishbein & Ajzen, 1975) and the social ecological model (Brofenbrenner, 1976) should be highlighted.

2.1. Social Cognitive Theory

One of the most important models used to understand human motivation and behavioural change is "Social Cognitive Theory" (Bandura, 1986). According to this theory, human motivation and action are regulated by control beliefs involving three types of expectations: a) Situation-outcome expectations, where the consequences are caused by environmental events, independently of personal action; b) Action-result expectations, where the result follows or is a consequence of personal action; and c) Self-efficacy expectations, referring to the person´s confidence in his/her ability to perform a task or achieve a certain result. Action outcome expectations and self-efficacy are crucial in the adoption of healthy behaviors, the elimination of prejudicial behaviors, and the maintenance of these behaviors.

Bandura (1997) described four sources of self-efficacy expectations. First, mastery experiences occur when a person is successful at accomplishing a task, and they have been shown to be the strongest way of increasing self-efficacy expectations for PA (Ashford et al., 2010; McAuley et al., 2011; Warner et al., 2014). Second, vicarious experience refers to the act of learning by observing others who are successful at performing a difficult task. In the case of PA, Ashford et al. (2010) found that vicarious experience can increase self-efficacy expectations.

Third, verbal persuasion refers to trying to convince someone about your ability to successfully perform a task. Research shows inconsistent results regarding the relationship between this process and self-efficacy expectations (Ashford et al., 2010). Finally, physiological and affective states influence the way a person judges his/her self-efficacy expectations. Positive affect prior to a task is thought to activate memories of previous successes and, thus, foster self-efficacy beliefs (Bandura, 1997).

Several studies found that self-efficacy expectations rank among the strongest predictors of initiating and maintaining PA (Sallis et al., 2000; Rimal, 2001; Van Stralen et al., 2009; Sterdt et al., 2014), even in an obese population (Olander et al., 2013). Research suggests that self-efficacy expectations correlated with the PA of children and adolescents (Nieman, 2002; Bauman et al., 2012; Gillison et al, 2017). In addition, self-efficacy expectations have also been related to perceived exertion (Ekkekakis et al., 2005), physical function performance (Rejeski et al., 1998), and affective responses during the practice of PA (Cameron et al., 2018).

Young et al. (2014) conducted the first systematic review assessing the usefulness of social cognitive theory to explain the PA practice without sample restriction. The results showed that these models explained 31% of the variance in PA behavior. Similarly, the effectiveness of this theory was moderated by the quality of the study and the age of the participants. The higher the quality of the study and the older the study participants, the greater the variance studied. This may indicate that PA practice in younger people is more driven by external factors such as parental influence than by cognitive factors.

2.2. The theory of self-determination

The theory of self-determination (SDT) is a macro theory of human motivation and personality that provides insight into the reasons people adopt and maintain health behaviours (Deci & Ryan, 1985; 2000). SDT suggests that the regulation of PA is supported by different levels of motivation, from intrinsic regulation to extrinsic regulation and amotivation. “Intrinsic

regulation" represents the most self-determined type of motivation, and it refers to engaging in PA for its own sake; intrinsically regulated people find PA inherently enjoyable, interesting, and challenging. "Extrinsic regulation" implies that the engagement with the behaviour is due to achieve outcomes. Thus, there is a continuum of external behavioural regulations according to the degree of autonomy: (a) *external regulation* involves being physically active to satisfy an external requirement; (b) *introjected regulation* represents motivation toward PA in order to avoid negative feelings; (c) *identified regulation* involved that the behaviour is performed more willingly due to personal importance and values, even though the activity is not enjoyable; and (d) *integrated regulation* is the most self-determined form on the extrinsic regulation continuum given that the behaviour is consistent with the person's other values and needs. Finally*, amotivation* is a state characterized by a lack of intention to engage in the activity. Studies have shown that autonomous types of behavioural regulation correlate with greater continuous PA in the general population (Teixeira et al., 2012), and in adolescents (Owen et al., 2014). Moreover, in general, the more autonomous types of behavioural regulation towards PA (e.g., intrinsic, integrated, and identified regulation) has been positively associated with enjoyment, and negatively associated with anxiety in PE (e.g., social physique anxiety). In fact, autonomous motivation has been shown to be more effective for mitigating the age-related decline in PA behaviour when is accompanied with higher enjoyment-related goals and lower social- and competence-related goals (Dishman et al., 2018). At the contrary, the more controlled types (e.g., introjected, external regulation and amotivation) have been negatively associated with enjoyment, and positively associated with anxiety in PA (e.g., Thogersen-Ntoumani & Ntoumanis, 2006; Zhang, 2009; Sánchez-Oliva et al., 2014; Sicilia et al., 2014).

According to Ryan and Deci (2007), self-determined motivation is more likely to be observed when individuals experience satisfaction of three basic psychological needs. These are the needs for autonomy (e.g., "I run of my own free will"), competence (e.g., "I am good at running") and relatedness (e.g., "I get along well with my running buddy"). In contrast, when

such needs are frustrated, individuals are likely to develop controlled or amotivated reasons for behavioural engagement. Another central concept of this theory is that the social environment is a key factor in supporting or thwarting individuals' psychological needs and, hence, promoting self-determined motivation for PA. Finally, the literature shows that the content of individuals' goals matter in terms of supporting vs frustrating the three psychological needs. Intrinsic goal content (e.g., health, affiliation) relative to extrinsic goal content (e.g., image and social recognition) is more likely to satisfy the three basic psychological needs (Sebire et al., 2009).

A systematic review by Teixeira et al. (2012) concluded that there is good evidence of the value of SDT for understanding PA behavior in the population. However, some inconsistencies and mixed evidence continue to exist with respect to the relationships between specific constructs of SDT and PA.

2.3. The Transtheoretical Model

One of the behaviour change theories used to guide PA interventions is the Transtheoretical Model (TTM) (Prochaska & DiClemente, 1983), which has been widely applied to promote PA behaviour (Hutchison et al., 2009).

According to the Transtheoretical Model (TTM) (Prochaska & DiClemente, 1983), individuals attempting to change their PA behaviour move through a series of stages (from Precontemplation to Action):

- *Precontemplation:* Individuals at this stage are not aware that their behavior is a problem. Therefore, these individuals will not consider modifying their behavior.
- *Contemplation*: Individuals at this stage are aware that a problem exists and consider changing their behaviour, although a commitment to do so has not yet been established.

- *Preparation:* Individuals at this stage make a decision and commit to change. At this point the individual begins to produce small behavioral changes.
- *Action:* Individual changes manifest behavior and covert behavior and environmental conditions.
- *Maintenance:* Individuals at this stage are trying to preserve and consolidate the progress made in the previous stage.

Several theoretical constructs are responsible for the movement through these stages: 10 processes of change (strategies people use to modify a behaviour; e.g. reinforcement management); self-efficacy (confidence about maintaining a behaviour change); and decisional balance (the pros and cons of behaviour change) (Prochaska & Velicer, 1997). The stages of change discussed above are useful in explaining when changes in cognition, emotion and behavior occur in individuals and the processes of change help to explain how these changes occur. Change processes need to be properly implemented to progress through the stages of change and achieve the desired behavior change. These processes can be divided into two groups: cognitive and affective processes (Consciousness Raising, Dramatic Relief, Environmental Reevaluation, Self-Reevaluation and Social Liberation) y and behavioural processes (Self-Liberation, Counter Conditioning, Helping Relationships, Reinforcement Management and Stimulus Control).

TTM theory includes elements of Social Cognitive Theory (Bandura, 1986), specifically the concept of self-efficacy. As discussed above, this concept refers to the degree of confidence that individuals have in maintaining the desired behavior even in high-risk situations. In the Precontemplation and Contemplation stages, the temptation to engage in the problem behavior is much greater than the self-efficacy to abstain. As individuals progress from Precontemplative and Contemplative states to Readiness and Action states, the gap between feelings of self-efficacy and temptation closes, and behavior change is achieved. Relapse often occurs in situations where feelings of temptation triumph over individuals' sense of self-efficacy to

maintain desired behavior change. Finally, decision-making was conceptualized by Janis and Mann (1977) as a decisive "balance sheet" of potential comparative gains and losses. Two components of the decision-making balance sheet, the pros and cons, have become central constructions of the TTM. As individuals progress through the Stages of Change, the decisional balance changes critically. When an individual is in the Precontemplation stage, the pros for behavior change are outweighed by the cons for change. In the Contemplation stage, the pros and cons tend to have the same weight, leaving the individual ambivalent towards change. However, if the balance of decisions is tipped in such a way that the pros for change outweigh the cons for maintaining unhealthy behavior, many individuals move to the Preparation or even Action stage. As individuals enter the Maintenance stage, the pros of maintaining the behavior change must outweigh the cons of maintaining the change to decrease the risk of relapse.

Some limitations have been found in the concept of stages of change, but other components, such as the process of change, seem to be promising in PA interventions (Armitage, 2009; Romain et al., 2018). Another limitation found in the research refers to what kind of change processes originate in the different stages (Marshall & Biddle, 2001). Despite this, TTM has shown its efficacy in promoting the maintenance of PA (Joseph et al., 2016).

2.4. The Theory of Reasoned Action

One of the most widely used socio-cognitive models to explain PA behavior is the theory of reasoned action (TRA) (Fishbein & Ajzen, 1975). This theory proposes that a central determinant of behavior is the personal intention to carry out that behavior. This intention reflects the level of motivation that an individual is willing to exercise to carry out that behaviour (Ajzen, 1991). Intention is determined by attitude, subjective norm, and behavioral control.

Attitude reflects the positive or negative evaluation of the realization of a behavior and is determined by the beliefs that the individual possesses and by the positive or negative evaluation made towards each one of those beliefs. The subjective norm refers to the perceived

social pressure to perform a behavior and is determined by the perception of the beliefs that significant others have about the behavior to be performed and by the individual's motivation to satisfy significant others about him or her. Finally, perceived behavioral control is defined as the perceived ease or difficulty of carrying out a behavior and is influenced by internal variables (perceived ability, ability to act) and by external variables (opportunities for action, obstacles, time, cooperation, etc.) Several studies show that this theory may be useful in explaining PA behavior (Plotnikoff et al., 2011; Huescar et al., 2014). However, there is also literature that questions the usefulness of this theory for proposing changes in behavior, among which is the PA practice (Sniehotta et al., 2014).

Hagger et al. (2002) conducted a meta-analysis with studies employing this theory in the PA context. The results showed an average effect size between intentions and PA participation. The effect of perceived behavioral control was less than the effect of intentions. While attitudes and perceived behavioral control predicted intentions, the effect of subjective norms on intentions varied considerably across studies. According to the literature, it is possible that subjective norms predict PA participation by younger individuals but not by older individuals (Hausenblas et al., 1997). Another meta-analysis by Webb and Sheeran (2006) revealed that medium and large changes in intentions led to small and medium changes in behaviour. However, interventions based on this theory have not always been successful in influencing PA practice. Studies have shown that changing attitudes towards PA is not always successful in motivating actual participation in PA (Chatzisarantis & Hagger, 2005).

2.5. Social Ecological Model

Social Ecological Models (SEM) are based on Bronfenbrenner's ecological systems theory (1979), the ecological model of health behaviour (McLeroy et al., 1988), and the social ecological model for health promotion (Stokols, 1992). These models propose that behavior is the result of interactions between individual characteristics (e.g., age, gender, Body Mass Index,

employment status), the social environment (e.g., family or peer social support, social norms), the physical environment (e.g., the environment of the home), and the social environment itself (e.g., climate, physical environment attributes such as green space, safety) and macro-environmental aspects, in particular policy (e.g. urban planning policies, workplace policies, active transport policies) (Ntoumanis et al., 2018). In summary, an individual's behavior is related to environmental and social constraints and enabling factors.

For example, a teenager may have a favorable attitude and intention to exercise (e.g., he knows that PA can help reduce his vulnerability to experiencing anxiety attacks, and he reports that he wants to sign up for athletics), and his parents support this idea. However, their family currently has little income because only the father works (so they cannot afford this activity) and there is no social assistance they can apply for. Similarly, they live in a conflictive neighborhood so the idea of doing sport outdoors is not safe and therefore not viable. This example illustrates how different obstacles can affect the decision to remain physically active despite favorable individual motivation. SEM recognizes that it is not enough to implement appropriate policies to change behaviour, if the individual is not motivated or does not intend to change his or her behaviour.

There is literature suggesting that a supportive physical environment can predict PA participation (Humpel et al., 2002; McGrath et al., 2015; Wang et al., 2016). In fact, there are studies that claim that these types of theories are more capable of explaining PA participation (Spence & Lee, 2003; Brownson et al., 2009; Thornton et al., 2017). However, there are also studies that reveal a lack of association between environmental characteristics and PA practice (Van Cauwenberg et al., 2011).

Finally, there are also studies that try to integrate SEM, with other theories of behavior change, some of which have been discussed previously. For example, Rhodes et al. (2006) examined how environmental perception interacted with variables related to TRA in predicting gait in adult individuals. The results revealed that attitudes mediated associations between

environment and walking and that the intention-behaviour relationship was reinforced for people who had greater access to recreational facilities. In addition, Gay et al. (2011) examined how the association between PA practice and psychological needs (derived from SDT) can be moderated by environmental perceptions. The results revealed that positive environmental perceptions reinforced the positive association between satisfaction of psychological need and PA self-reported. D'Angelo et al. (2017) examined how both TRA and SDT variables interacted with environmental perceptions in predicting self-reported minutes of moderate-to-vigorous PA in a sample of adolescents. The results showed that some neighborhood characteristics that supported PA reinforced the associations between TRA variables and moderate-vigorous PA, and between more controlled autonomous motivation with moderate-vigorous PA. Finally, Merom et al. (2009) showed that motivational variables derived from Social Cognitive Theory (Bandura, 2001) could nullify the effects of an unfavorable physical environment on gait prediction.

Recently, researchers have suggested that theoretical integration may be a viable way to improve our understanding of PA behaviour by reducing complexity through the elimination of redundant variables (Hagger & Chatzisarantis, 2009).

Many of the interventions that have been based on these models and theories (Social Cognitive Theory, The theory of self-determination, The Transtheoretical Model, The Theory of Reasoned Action, and Social Ecological Model) have shown their effectiveness mainly in the short term. In addition, there are some barriers that, by using these theories and models, can be understood but cannot be easily addressed. In this context, the need arises to continue exploring new ways to promote the PA practice.

3. Technologies and physical activity promotion

Technologies have traditionally been considered as promoting sedentary behavior (Griffiths, 2010). However, the use of technology can help us combat each of the barriers to PA

practice, taking into account the theories and models that have been cited above and that are at the base of effective traditional interventions aimed at promoting the practice of PA. Below, we explain the role that technologies have had and still have in promoting well-being and the PA practice.

3.1. The negative impact of technologies

To date, research has shown that sedentary lifestyles are heavily influenced by increasing technological development (Griffiths, 2010). Some examples that explain the decrease in daily PA are the increased use of cars, automated household appliances, the use of lifts and escalators, the use of televisions and computers as a main source of entertainment and leisure, and the use of e-mail as a means of communication (Goran & Treuth, 2001; Nigg, 2003).

Research on the use of television and video games tends to show associations between this technology and sedentary lifestyles and obesity (Vandewater et al., 2004; Marshall et al., 2004). Screen time has been linked to increased obesity in children (Pagani et al., 2010; Fitzpatrick et al., 2012) and adolescents (Casiano et al., 2012; Do et al., 2013). In general, excessive use of technology is linked to lifelong obesity and cardiovascular risk, and this relationship is observed from early childhood (Bel-Serrat et al., 2013). It has been argued that screen time promotes obesity through two vehicles: poor eating habits and/or lack of exercise (Rosen et al., 2014).

People of all ages are spending more time interacting with technology (e.g., Internet, video games, interactive TV, mobile phones, MP3 players, etc.). For adults, the increase in time is mainly related to work, while for adolescents it is more related to leisure (Griffiths, 2002; 2003; 2009). In general, activities that were previously performed in an external environment can now be performed at home and/or in the workplace (Griffiths & Wood, 2000; Griffiths, 2003). Similarly, work and leisure have become increasingly technical and remote (Griffiths, 2002; 2009; Widyanto & Griffiths, 2006).

Technology has also changed the way society relates (Griffiths, 2003). Although many people make asocial use of technology (e.g., a single person engaging in some type of screen-based activity), many of the activities performed are social activities (e.g., playing an online video game with others). New (increasingly social) types of technology may have important implications for obesity (Griffiths, 2010).

Research has also shown that excessive screen use, including television, video games, and the Internet, predicts poorer health and involvement in negative health behaviors such as increased cholesterol and insulin on an empty stomach, lower cardiovascular fitness, worse sleep habits and less healthy eating patterns, higher smoking rates, depressive and anxiety symptoms, concentration problems, and musculoskeletal problems (Kelly et al., 2009; Martin, 2011).

3.2. Technologies as allies for the promotion of well-being

Technology is embedded in our society and is changing our lives in both positive and negative ways. In the context of PA, technologies can be seen as a double-edged sword, considering their relationship with sedentarism but also the positive impact they can have on PA. Computers, internet use, online media, electronic and mobile device applications for health, global positioning and geographic information systems, active video games (video games that requires interactive PA) and virtual reality (VR) have proven to be useful tools for assessing and promoting healthy behaviors including PA (Gao & Lee, 2019).

This dissertation focuses on VR. The following defines VR and its usefulness in promoting well-being and PA practice.

3.3. Conceptualization of virtual reality

VR can be defined as a technology that allows the generation of "analogues" of the real world. Specifically, this type of technology consists of computer-generated worlds that can be

virtually indistinguishable from the real world. Through this, it is possible to create artificial experiences in real time, making the user feel immersed and able to interact as if it were the real world (Botella et al., 2017). VR can generate new forms of human-machine interaction, as the media becomes part of ourselves, extensions of the senses (McLuhan, 1964). The key feature of VR, which differentiates it from other media or communications is the sense of presence (Ijsselsteijn et al., 2001; Riva et al., 2003). Presence is defined as the "sense of being there", or as the "feeling of being in a world that exists outside of the self" (Riva et al., 2003). VR users come to believe that the experience is real and that they are really there. In this context, the inhabitants of virtual environment (VE) can be classified as bots or agents and avatars. A bot is an autonomous agent that pursues its own objectives. In contrast, an avatar is a representation of a human being that is under the direct control of that human being (Whalen et al., 2003).

The VR system can be more or less immersive. In immersive systems, projection screens are used to create a virtual background. In addition, the user wears a head-mounted display (HMD). In non-immersive systems, the VE is viewed through a portal or window using a monitor. Interaction occurs through the use of conventional media such as keyboards and mice or through the use of three-dimensional interaction devices (Gao & Lee, 2019). A semi-immersive system shall comprise a relatively high-performance computer graphics system that can be coupled with a large-screen monitor, a large-screen projector system and a multi-television projection system (Alhadad & Abood, 2018). Immersive VR makes players feel as if they are "really in the virtual world", while non-immersive VR does not simulate a VE to any great extent (Sanchez-Vives & Slater, 2005).

3.4. Virtual reality in the field of health and psychology

The first healthcare applications of VR began in the early 1990s with the need for medical personnel to visualize complex medical data during surgery and during planning (Chinnock, 1994). Since then, there has been a growing interest in studying the medical applications of VR

(Riva, 2003). Numerous clinical trials and meta-analytic reviews and studies have provided evidence of its usefulness for various clinical conditions (e.g., anxiety disorders, stress-related disorders, psychosis, eating disorders, and health conditions) (Botella et al., 2017). VR has also been shown to be useful for the assessment and rehabilitation of cognitive functions such as attention, memory, spatial skills and others in both clinical and general populations (Rose et al., 2005; Parsons et al., 2009; D'Cunha et al., 2019).

Similarly, VR has proven to be a useful tool in the context of medical education and training. Specifically, Pensieri & Pennacchini (2014) conducted an overview of existing research on the topic. VR has been used to teach different types of skills in a medical context (Jeffries et al., 2003). For example, the literature shows that from virtual worlds, clinicians and students can understand important physiological or basic anatomical principles. In this context, VR can be used both as a didactic tool and for experimental teaching, allowing a greater understanding of the interrelationship of anatomical structures that cannot be achieved by any other means. Virtual worlds also can be used to inform, educate and improve patients' knowledge of health (Kamel Boulos & Toth-Cohen, 2009). In addition, numerous studies have concluded the analgesic effect of VR in a medical context (Mott et al., 2008; Sharar et al., 2008; Hoffman et al., 2011).

3.5. Virtual reality and physical activity promotion

VR makes it possible to influence the variables and mechanisms present in the above-mentioned models, which seek to promote PA. Similarly, VR allows us to overcome internal and external barriers in the PA practice that cannot be influenced by traditional methods. The following specifically details how VR can promote and improve PA practice.

The use of VR is already considered a new method to promote healthy behaviors among which is the practice of PA (Ahn & Fox, 2017). VR was first applied to sports research in the 1990s, although there has been a resurgence of interest in recent years (Neumann et al., 2018). VR applied to sport can be defined as the cases in which people practice a sport represented in

a computer-simulated environment that aims to induce a feeling of being mentally or physically present and allows interactivity with the environment (Alhadad & Abood, 2018). This definition highlights the computer-simulated nature and interactivity of the VE, which are key elements of the broader definitions of VR (Baños et al., 2000; Sherman & Craig 2002; Neumann et al., 2018).

Outside the sports context, the VE is usually displayed using a virtual computer automatic environment (CAVE) or head-mounted display (HMD) (Slater, 2009). The CAVE can be defined as a large cube formed by screens where the user physically enters to surround himself with the VE. An HMD is a wearable device as it covers the eyes and thus eliminates the view of the outside world. It has one or more small screens on which the virtual world is seen in stereo vision with a wide field of view. The HMD combines with head tracking to allow the user to see areas of the VE that are outside the immediate field of vision. However, in the sports context, potential applications for the use of CAVE and HMD systems may be limited. In relation to HMD, it may be impractical and dangerous for some sports, due to issues related to discomfort and vision. In this context, it is most common to use a two-dimensional representation of the VE using a computer screen or projector (Slater, 2009).

The application of VR to sport has several strengths (Alhadad & Abood, 2018). On the one hand, the VE can be controlled and manipulated, so it can be useful to physically train individuals. VR can be used to perform assessment, obtain performance information and practice specific skills. Sporting activities that are dangerous or expensive for individuals can be undertaken through VR programs. In addition, the VE is not always individual but allows for the inclusion of other individuals who are physically located elsewhere. Finally, no specialist technical knowledge is required for their use so VR programs can be used in gyms as well as in the home (Hoffman et al., 2014). Another advantage of this technology is that it allows to overcome possible negative environmental influences such as climate (Plante et al., 2003). As concluded in a recent review, the main advantages of using VR in PA and sport can be grouped into four central themes, availability, cost reduction, realism and security (Nor et al., 2020).

Therefore, it can be deduced that through VR many of the barriers that individuals find in the PA practice can be overcome.

In addition, the use of VR has a number of advantages over other more traditional technologies. In an overview carried out by Chow et al. (2017), it became evident how VR can be a useful means of changing attitudes and behaviour in areas of health care, among which is the practice of PA. These authors described that the use of technologies such as VR had a series of advantages over more traditional technologies. For example, VR allow for greater interactivity (through VR the user can interact with the VE in real time, which promotes a better understanding by the user of the cause and effect relationship between their actions and results), and it allows for the presentation of content in a multimodal way, which creates more compelling and attractive experiences for the user. These features turn VR into an entertaining technology that motivates users to change attitudes and behaviour. Similarly, VR enables greater accessibility to the population and it is an intuitive technology. Many individuals have previous experience with other VR games, and this experience can be transferred, with minor adjustments, to new games.

VR offers new learning possibilities for training individuals to perform physical movements such as physical therapy and exercise (Bailenson et al., 2008). The literature shows that VR can be useful in influencing the amount of PA performed, psychological variables that are related to practice, and also the physical execution and performance in some tasks. Regarding the psychological variables related to PA practice, several studies show how VR can influence motivation towards PA, self-efficacy, enjoyment during its practice and perception of effort, being these variables key barriers and facilitators of PA practice. Finally, VR has also shown its influence on physical variables related to performance, such as variability heart rate.

The following are the main systematic reviews that justify the different influences of VR on the PA practice. These reviews have been ordered chronologically in order to represent how the application of VR to sport has evolved and the conclusions drawn. The last of the reviews

conducted on the topic highlights the need to replicate studies that primarily explore the effects of VR settings on psychological variables related to PA practice.

Papastergiou (2009) conducted a systematic review, which concluded that this technology had the potential to improve physical aptitudes, motor skills and motivation to engage in PA. In terms of the acquisition of motor skills, the authors concluded that sports simulation games are useful for teaching these skills and it is possible to transfer this knowledge to real life under certain conditions (e.g., Fery & Ponserre, 2001). In terms of improving physical aptitude, the authors point out that interactive physical games can increase motivation towards PA, can provide alternative ways of engaging in PA and consequently can help combat obesity. PA through interactive video games meets the recommendations for obtaining the benefits of traditional PA, there is no risk of injury, and it leads to greater enjoyment and motivation (e.g., Tan et al., 2002; Unnithan et al., 2006; Sell et al., 2007). This review highlights the potential of such technologies to complement, for example, physical education classes.

In this same context, Pasco (2013) conducted a systematic review of the role of VR in PA and its possible application in physical education classes. This author concluded that VR technology can be a useful learning tool in PA environments. For example, VR technology can be useful for learning motor skills (although this depends on the specific skill type). Research suggests that VR works better with closed motor skills (e.g., Thai Chi movements) compared to open motor skills (e.g., catching a ball at a baseball game) (e.g., Eaves et al., 2011). Furthermore, the influence of this learning on real life seems limited and is not always achieved (e.g., Zaal & Bootsma, 2011). In addition, VR technology has been seen as an opportunity to study and improve physiological responses to exercise in a safe, controlled and motivating way. Studies on the impact of VR on physiological responses are still scarce but research suggests that this technology can help individuals optimize their exercise routines and increase the behavioural and physiological benefits of exercise (e.g., Chuang et al., 2003). In terms of individuals' experience and performance, individuals using high-immersion VR environments experienced

greater presence perception, and reported more competence, control, interest and perceived enjoyment (e.g., Ijsselsteijn et al., 2004).

Biddiss & Irwin, (2010) conducted a systematic review of metabolic spending and changes in activity patterns associated with the use of interactive VR applications. The results revealed that the use of this technology increased activity level, caloric expenditure and heart rate (e.g., Maddison et al., 2007; Sell et al., 2008; Mellecker & McManus, 2008; Inzitari et al., 2009). In addition, energy expenditure was lower for games that used the upper body compared to games that used primarily the lower body (e.g., Graf et al., 2009; Lanningham-Foster et al., 2009; Graves et al., 2007). These authors concluded that this type of technology was useful in promoting light to moderate PA intensity. However, they also state that there is still limited evidence to draw conclusions about the long-term effectiveness of these video games. Therefore, further studies are needed to support the effectiveness of this technology in the field of PA.

Warburton (2013) conducted a review on the health benefits of using VR environments. The literature included in this review provides evidence of the health benefits of interactive VR games and the suitability to promote and improve the practice of PA. Several studies concluded that it was a viable means of improving PA levels and reducing sedentary behaviors in a wide range of individuals (e.g., Ni Mhurchu et al., 2008; Guy et al., 2011). Similarly, it was concluded that active play leads to greater enjoyment during activity, greater adherence, better health and greater metabolic demands compared to traditional training (e.g., Rhodes et al., 2009). In addition, this technology had the potential to distract from fatigue and reduce perceptions of exertion at a certain exercise intensity (particularly during moderate-intensity exercise), and helped improve body composition in overweight or obese children (e.g., Maddison et al., 2011; Maddison et al., 2012).

The review conducted by Molina et al. (2014), focused on older adults, who had not been included in the previously discussed reviews. These authors reviewed the literature to date on the effects of VR and active video games on the physical functioning of older adults. Among the

articles included in this review, it can be seen that in general it seems that this technology has shown evidence in some measures related to physical functioning such as posture, gait, and balance (e.g., Szturm et al., 2011; Toulotte et al., 2012; Pichierri et al., 2012; Duque et al., 2013). In addition, it appears to be a useful tool for increasing older adults' time in activity (e.g., Jorgensen et al., 2013). However, the greatest consensus so far was on the positive motivational aspect of using this technology (e.g., Franco et al., 2012; Maillot et al., 2012; Schoene et al., 2013). The authors of this review claim that there was little methodological quality and that stronger scientific evidence was needed.

Crocetta et al. (2015) conducted a review of the effect of VR and augmented reality on physical performance. This review selected a number of papers that showed that video games using VR and augmented reality effects are already being used as an everyday working tool by physical therapists, occupational therapists, and physical education professionals. According to the studies reviewed in this article, video games and computer programs that use VR and augmented reality motivate PA and contribute to improving health, providing moments of pleasure and learning in individuals, as well as reducing levels of perceived fatigue (e.g., Nascimento et al., 2013; Sposito et al., 2013; Souza et al., 2013; Plante et al., 2003).

Neumann et al. (2018) conducted a systematic review on the application of interactive VR to sport. In this review, the authors concluded that interactive VR applications improved performance (e.g., adherence, distance, speed, physical intensity exercised, persistence in the task and strategy) (Ijsselsteijn et al., 2004; Anderson-Hanley et al., 2011; Irwin et al., 2012; Snyder et al., 2012; Hoffmann et al., 2014; Chen et al., 2015; Murray et al., 2016), the physiological effects of PA practice (e.g., heart rate, oxygen consumption and blood lactate level, muscle fatigue and electroencephalogram amplitude and frequency) (Snyder et al., 2012; Nunes et al., 2014; Chen et al., 2015; Oliveira et al., 2015; Vogt et al., 2015), and the psychological effects (e.g., motivation, perceived effort, distraction from bodily sensations during exercise,

and positive and negative emotional states) (e.g., Ijsselsteijn et al., 2004; Mestre et al., 2011; Anderson-Hanley et al., 2012; Nunes et al., 2014; Baños et al., 2016).

However, these authors also argued that such results were not always found because there are moderating variables explaining these influences. These variables are mainly related to the VR system and to the user. In relation to the VR system, one must take into account the presence of others in the VE, competitiveness, task autonomy, immersion, attention span and feedback (e.g., Ijsselsteijn et al., 2004; Anderson-Hanley et al., 2011; Irwin et al., 2012; Snyder et al., 2012; Nunes et al., 2014; Murray et al., 2016). All these aspects seem to enhance the influence of VR on PA. Regarding the user, the authors argued that these effects were also influenced by factors related to the individual (e.g., physical characteristics, expertise and experience, and psychological characteristics) (Plante et al., 2003; Legrand et al., 2011; Hoffmann et al., 2014; Oliveira et al., 2015). Similarly, these authors noted that most of the research had been conducted on sports, such as running, cycling, and rowing. For this reason, the authors felt that more research was needed to examine the use of interactive VR in skill-based sports.

Finally, Yu-Leung et al. (2019) recently conducted a review on the effectiveness of VR for enhancing PA practice. This review once again showed that this technology has been used primarily to make comparisons between the effectiveness of VR-supported physical exercise and traditional physical exercise in relation to the amount of PA performed (e.g., frequency, intensity, and duration), psychological measures related to practice (calmness, energy, enjoyment, tension, and fatigue), and physical execution (balance, walking, and strength). However, in this case, these authors concluded a large effect size of VR on PA level, a small effect size on performance and no effect on psychological outcomes. Therefore, according to this review, VR-supported PA programs can improve and increase PA adherence. In many cases, VR also be able to improve performance on certain physical tasks. In contrast, the psychological

effects of PA appear to be the same using RV-supported training as using non-RV-supported training.

According to this latest review, although there are many studies that support the use of VR to promote PA, more studies would be needed to analyze whether VR specifically improves physical performance and psychological variables associated with PA practice.

3.6. Avatars and physical activity promotion

The inhabitants of VR environments called “avatars” are receiving a lot of attention in recent years, as they have been shown to influence some of the variables and mechanisms directly related to PA and help overcome some of the most important barriers, such as the absence of motivation towards PA, the absence of self-efficacy and competence, the absence of enjoyment and barriers related to the perception of one's body during the PA practice.

The word "avatar" originates from the Sanskrit word avatara, which means "descent" to describe an incarnation or a bodily manifestation of an immortal being in Hinduism (Ahn, 2015). In a very similar way, users interact in the virtual world in the form of embodied virtual identities that mark their presence in the VE (Ahn et al., 2012). In the past, avatars were much simpler and static visual representations. Over time, avatars have become more complex represented in three-dimensional forms with a wide range of dynamic movements, very realistic appearances, naturalistic language, and even the ability to imitate empathy when interacting. Agents are another form of virtual representation that share similar characteristics and capabilities with avatars, but the two forms are distinguished by the element of control: avatars are controlled by human users, while agents are controlled by computer algorithms (Bailenson & Blascovich, 2004).

Although apparently very similar, agents and avatars exert significantly different influences on their interactions with human users (Blascovich, 2002). Research has shown that the mere perception of interacting with another human (as opposed to a computer algorithm)

significantly affects whether a virtual representation is successful in influencing an individual's attitude and behaviour, even when agents and avatars are performing identical tasks (Okita et al., 2007; Lim & Reeves, 2010).

Various studies show that observing and interacting with these representations allows individuals to immerse themselves in the virtual world and come to feel that they are actually present in the situation (Fox et al., 2009; Ahn et al., 2014; Ahn 2015), increases self-efficacy towards achieving health goals (Ahn et al., 2015), and promotes thinking about health risk as an important fact (Ahn et al., 2014; Ahn, 2015). In addition, the health behaviours driven by these representations persist longer than the same information provided through other, more traditional channels (Fox, & Bailenson, 2009; Fox et al., 2009; Ahn et al., 2014; Ahn, 2015). These representations can be combined with play mechanisms to replace total sedentary time with PA while playing video games (Biddiss & Irwin, 2010; Staino et al., 2013). Specifically, the literature shows that the use of avatars increases levels of PA, since they influence the perception of activity, making it more enjoyable, increasing autonomy and competence (Thompson et al., 2018).

Other more recent reviews on the subject include the physical appearance of the avatar as a variable to consider (Clark et al, 2019; Peña et al., 2020). Clark et al (2019) analyzed the influence of the avatar's physical appearance on health-related outcomes. These authors claimed that the most consistent result appears to be the effect of exercising as an 'obese', compared to 'normal' sized avatars, on performance in the selected activity. This result has been studied in children, and older adults, men and women. According to the literature, it could be said that there is an inverted U-shaped relationship between the avatar's appearance and exercise behavior. The use of overweight and over-muscular/idealized avatars can reduce exercise performance or body satisfaction respectively, while an optimal level of performance can occur between the two extremes. Regarding such conclusions, despite being the most consistent result, the authors in this review state that currently there are still not enough data

to support this model and more studies are needed to replicate this idea. Similarly, the range of body types used within the set of appearance-related studies has been restricted to the thin/athletic and overweight/obese sides of the spectrum.

Regarding the physical appearance of the avatar, Peña et al. (2020), argue that embodying avatars with certain stereotypical physical characteristics can influence PA. For example, Peña & Kim (2014) found that women showed higher levels of PA measured with accelerometers when they embodied thin avatars, compared to when they embodied obese avatars. Similar results were found when the sample was composed of men (Peña et al., 2016). This review attempts to explain why the physical appearance of the avatar has these effects. The authors explain this by the "Proteus Effect", which predicts that individuals adapt their behavior to their avatar's identity and what they believe is expected of their virtual person (Yee & Bailenson, 2007). This effect tries to explain how the physical appearance of the avatar (e.g. weight, attractiveness, etc.) can influence behaviours or cognitions during the use of VR environments. According to Yee and Bailenson (2007), the Proteus effect is linked to self-perception theory (Bem, 1972), in which an avatar's appearance triggers a temporary change of self-concept (Bem, 1972). According to Peña et al., (2009), the Proteus effect is grounded on automatic priming mechanisms, which predict that activating a concept or stereotype triggers associated thoughts and behaviors while inhibiting contrary concepts (Bargh et al., 1996). In this context, Li et al., (2014) analyzed the effects of embodying a thin or obese avatar and exposure to the stereotype as such. Participants who incarnated an overweight avatar performed the PA task worse than those who incarnated a thin avatar. In addition, those who explicitly receive the stereotype did worse than those who did not receive the stereotype.

Another aspect discussed in these reviews (Clark et al., 2019; Peña et al., 2020) is the personalization of avatars and their influence on health-related behaviour. These authors concluded that overall, participants who personalized their avatars had a higher self-report of behavioral intentions, as measured by the percentage of time they intended to spend on

maintaining good health. However, intentions and actual behaviour associated with such intention did not always correlate and results did not always go in the same direction (e.g., Kim & Sundar, 2012). The avatar customization has been shown to improve users' identification with their avatar (Turkay & Kinzer, 2014), motivation to play games (Birk et al., 2016), enjoyment and exercise during an exergame (Li & Lwin, 2016). In this context, the difference between the real self, the ideal self and the self that should be has also been studied. The actual self is a representation of the attributes an individual actually possesses. The ideal self encompasses attributes an individual would ideally like to possess. The self that should embody attributes that an individual believes he should possess (Higgins, 1987). Literature has shown that the mere personalization based on these concepts had no influence, positive or negative, on health-related outcomes such as PA practice. For this reason, more research is needed in this area.

For example, Kim and Sundar (2012) hypothesized that the real self would lead to a greater perception of risk to the body in health-related issues. However, of the three scales they used to measure this effect, only one supported this hypothesis. Other studies have compared the real self and the ideal self (Darville et al., 2018; Jin, 2012; Kim & Sundar, 2012; Sah et al., 2016), and have found no differences between the groups in any health-related outcomes. In relation to "should be", it is the projection of what a person feels they should be morally. This model of self-control was only used in one study (Sah et al, 2016), and the authors reported that by controlling for health awareness, participants selected fewer foods compared to the actual condition of body activation.

In this context, studies by Fox & Bailenson (2009) show that individuals are more likely to learn healthy behaviors such as PA after seeing an avatar that looks like themselves, which is consistent with the principles of vicarious learning and imitation based on similarity perception. These authors analyzed the effectiveness of immersive VR environments for modelling PA practice. To do so, participants saw their virtual selves performing PA from the point of view of a third person. The findings revealed that seeing the virtual self-rewarded for engaging in

exercise behavior and then punished for not engaging in it encouraged exercise behavior. Simply being immersed in a VE or seeing the static virtual representation in a VE while exercising was not enough. Watching the virtual representation of the physical self lose weight according to one's physical exercise and seeing the virtual representation of the physical self gain weight due to physical inactivity effectively encouraged participants to exercise. This study determined that the virtual self is a model that can be used to encourage exercise. Similarly, Li & Lwin (2016) concluded that a key factor in learning health behaviours is the similarity between the model and the self. There is a close relationship between identification with avatars, enjoyment of the experience and motivation. Individuals who perform avatar interventions in virtual worlds, compared to those who do not use them, show greater self-efficacy toward exercise and nutrition (Behm-Morawitz et al., 2016).

Finally, Horne et al. (2019) conducted a specific review on the use of avatars in weight loss interventions. These authors concluded that the use of avatars in weight loss interventions leads to greater weight loss and maintenance compared to traditional interventions (Behm-Morawitz et al., 2016; Ossolinski et al., 2017). The ability to customize avatars may provide additional benefits by motivating individuals to adhere to weight loss (Napolitano et al., 2013; Ossolinski et al., 2017). Individuals who use avatars are more committed to weight loss programs (Johnston et al., 2012; Napolitano et al., 2013; Manzoni et al., 2016), are more likely to achieve their weight loss goals (Johnston et al., 2012; Behm-Morawitz et al., 2016), and are more likely to maintain it longer (Cesa et al., 2013; Manzoni et al., 2016). In relation to the practice of PA, the use of avatars seems to increase self-efficacy towards exercise. However, this did not translate into increased PA in real life (Johnston et al., 2012). The reasons behind this are still uncertain and have not been directly discussed by the authors and therefore deserve to be further explored. It is possible that this is related to increased bodily self-awareness as a result of avatar involvement, although the evidence from Manzoni et al. (2016) and Cesa et al. (2013) contradicts this perspective, creating uncertainty about the underlying causal factors.

In summary, the literature shows that the use of avatars in VR environments is a useful tool to promote PA practice as they allow the influence of variables and mechanisms such as motivation towards PA, self-efficacy, and enjoyment. Similarly, the physical appearance of the avatar can be manipulated to influence some of the barriers that cannot be addressed by more traditional methods. In this context, there are different aspects related to the appearance of the avatar about which nothing can be concluded yet. Although the literature seems to show that certain characteristics related to the appearance of the avatar can influence the practice of PA (e.g., the body dimensions of the avatar or avatar personalization), existing studies are still scarce and limited. It is necessary to replicate these studies with different samples as well as to study other characteristics related to the physical appearance of the avatar.

4. Outline of this dissertation

This dissertation has several general objectives. Firstly, our interest was focused on the analysis of motivation towards PA practice in adolescents. To do so, we validated the BREQ-2 questionnaire in the Spanish adolescent population and analyzed the role of motivation in PA practice in this population. Secondly, our objectives focused on analyzing the influence of VR environments and virtual representations of users on PA practice and specific interventions designed to promote this behavior.

The **general objectives** of this dissertation are:

1) To validate the psychometric properties of an instrument aimed at assessing different levels of motivation towards PA in the Spanish adolescent population, as well as to analyze the differences in motivation according to sex and age; and the role of age and sex in the relationship between motivation and enjoyment of PA.

2) To analyze the influence of using VR to influence the PA practice and physical and psychological variables related to its practice.

3) To investigate the influence of the avatar's physical appearance on the practice of PA and physical and psychological variables related to the practice in several populations.

4) To investigate the effectiveness of using avatars to complement existing online interventions to improve PA practice.

Study 1 is aimed at validate the psychometric structure of the *Behavioural Regulation in Exercise Questionnaire- 2* (BREQ-2) to confirm the existence of five levels of motivation toward PA in Spanish adolescent population; as well as to analyse the differences in motivation according to sex and age; and the role of age and sex in the relationship between motivation and enjoyment. **Study 2** is presented in chapter 3, entitled "The influence of success or failure in the practice of physical activity in children: Manipulating the outcome in a virtual reality task". It is designed to manipulate the outcomes on PA task in a VR environment, and analyze its effects on several variables (subjective tiredness, affect, arousal, speed, and heart rate), and to exploring the moderation role of self-efficacy and motivation. Chapter 4 presents **Study 3** entitled "The effects of avatar appearance on physical activity: Testing social cognitive theory, proteus effects and goal-gradient predictions on cardiac frequency and step counts". It is designed to tested social cognitive theory and the Proteus effect predictions regarding how avatars can incentivize PA. Finally, **Study 4** entitled "Manipulating self-avatar body dimensions in virtual worlds to complement an Internet-delivered intervention to increase physical activity in overweight women". The main objective of this study is to investigate the use of avatars and their physical variations to extend the effectiveness of existing interventions to promote PA. The main objective is to analyze the influence of the avatars' body dimensions on the efficacy of an Internet intervention to increase PA levels and improve other relevant variables (motivation toward PA, enjoyment, anxiety, self-efficacy, and PA goals).

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CHAPTER 2. Study 1

Adolescent motivation toward physical exercise: the role of sex, age, enjoyment, and anxiety

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Abstract

Physical Exercise (PE) declines during adolescence due to several factors, such as lack of intrinsic motivation or enjoyment, high PE anxiety, etc. The objectives of the present study were to validate the psychometric structure of the *Behavioural Regulation in Exercise Questionnaire-2* (BREQ-2) to confirm the existence of five levels of motivation toward PE in adolescent population; as well as to analyse the differences in motivation according to sex and age; and the role of age and sex in the relationship between motivation and enjoyment. To do so, 666 students between 10-16 years old completed the BREQ-2 and questionnaires related to enjoyment and PE anxiety. The confirmatory factor analysis of the BREQ-2 showed a 5-factor structure. However, a more parsimonious 4-factor structure with a single intrinsic-identified regulation emerged through an exploratory factor analysis. The more self-determined types of motivation were positively associated with enjoyment and negatively with anxiety, the type of PE motivation fluctuated depending on age and sex, and the age moderated the relationship between motivation and enjoyment. This study highlights the importance of fostering specific types of motivation to improve the PE and the relevance of age and sex when developing interventions.

Keywords: Motivation; Self-determination theory; Physical exercise; Enjoyment; Anxiety.

1. Introduction

Physical Exercise (PE) is an important health-related behaviour that allows better weight control and health (Reiner et al., 2013). Furthermore, it has other relevant psychological benefits, such as reducing anxiety and depressive symptoms (Rebar et al., 2015; McMahon et al., 2017). Despite the benefits of engaging in regular exercise, it declines with age, especially in adolescence (Sanchez et al., 2007; Van der Horst et al., 2007; Dumith et al., 2011). A recent meta-analysis has determined that this progressive decline of the moderate-vigorous intensity PE is produced even before adolescence, starting between the early- and mid-childhood (Farooq et al., 2020). Many factors may contribute to this, such as lack of intrinsic motivation, concerns about perceived physical appearance, social anxiety in PE, or lack of enjoyment (e.g., Robbins et al., 2003; Babic et al., 2014; Owen et al., 2014; Lewis et al., 2016).

The theory of self-determination (SDT) is a macro theory of human motivation and personality that provides insight into the reasons people adopt and maintain health behaviours (Deci & Ryan, 1985; 2000). SDT suggests that the regulation of PE is supported by different levels of motivation, from intrinsic regulation to extrinsic regulation and amotivation. "Intrinsic regulation" represents the most self-determined type of motivation, and it refers to engaging in PE for its own sake; intrinsically regulated people find PE inherently enjoyable, interesting, and challenging. "Extrinsic regulation" implies that the engagement with the behaviour is due to achieve outcomes. Thus, there is a continuum of external behavioural regulations according to the degree of autonomy: (a) *external regulation* involves being physically active to satisfy an external requirement; (b) *introjected regulation* represents motivation toward PE in order to avoid negative feelings; (c) *identified regulation* involved that the behaviour is performed more willingly due to personal importance and values, even though the activity is not enjoyable; and (d) *integrated regulation* is the most self-determined form on the extrinsic regulation continuum given that the behaviour is consistent with the person's other values and needs.

Finally*, amotivation* is a state characterized by a lack of intention to engage in the activity. Studies have shown that autonomous types of behavioural regulation correlate with greater continuous PE in the general population (Teixeira et al., 2012) and in adolescents (Owen et al., 2014). Moreover, in general, the more autonomous types of behavioural regulation towards PE (e.g., intrinsic, integrated, and identified regulation) has been positively associated with enjoyment, and negatively associated with anxiety in PE (e.g., social physique anxiety). In fact, autonomous motivation has been shown to be more effective for mitigating the age-related decline in PE behaviour when is accompanied with higher enjoyment-related goals and lower social- and competence-related goals (Dishman et al., 2018). At the contrary, the more controlled types (e.g., introjected, external regulation and amotivation) have been negatively associated with enjoyment, and positively associated with anxiety in PE (e.g., Sánchez-Oliva et al., 2014; Sicilia et al., 2014; Thogersen-Ntoumani & Ntoumanis, 2006; Zhang, 2009).

In addition, sex and age seems to have an important role in the behavioural regulation in PE. Butt et al. (2011) found that adolescent girls -specially, older girls- participate in less PE than adolescent boys. One possible explanation could be that boys and girls are attracted to PE for different aspects. For instance, boys may be more attracted to the exertional characteristics, while girls may be more attracted to PE for aspects such as the popularity gained with their peers or the improving of the body image. Egli et al. (2011) found that males are more motivated by intrinsic factors (e.g., challenge) whereas females are more motivated by extrinsic factors (e.g., weight management). In a recent study (Portela-Pino et al., 2020), boys and girls between 12 and 17 years old showed different motives for doing PE (e.g., competition/ social recognition/ challenge/ affiliation/ fun/ well- being/ muscle/ endurance/ health emergencies in the case of boys, and weight/body image/agility/flexibility in the case of girls), and girls showed significantly more barriers for doing PE than boys (e.g., physical social anxiety/fatigue/laziness).

Therefore, to develop successful interventions that promote PE in adolescent population, it is important to examine behavioural regulation in PE. The Behavioural Regulation in Exercise

Questionnaire (BREQ) measures the degree of autonomy in PE behaviour, and it has been used to examine the processes related to the regulation of PE. It was developed by Mullan, et al. (1997) to assess four types of motivation toward PE (external, introjected, identified, and intrinsic regulation) in adults. Later, Markland, and Tobin (2004) developed the BREQ-2 and added amotivation. The BREQ-2 has showed the same factorial structure and has demonstrated reliability and validity for use with adults in Spanish (Moreno-Murcia et al., 2007), Chinese (Liu et al., 2015), or Iranian (Farmanbar et al., 2011). In the same line, versions for adolescents have been validated, such as in Belgian (Verloigne et al., 2011), Romanian (Crăciun & Rus, 2012), and Chinese (Chen et al., 2018).

The objectives of this study are to confirm the existence of five levels of motivation toward PE in adolescent population through a confirmatory factor analysis, the internal consistency and the nomological validity of the Spanish version of the BREQ-2 (Moreno-Murcia et al., 2007); to analyse the differences between sex and age groups in the different types of behavioural regulation in PE; and to explore the role of age and sex in the relationship between the different types of behavioural regulation in PE and enjoyment of PE. We hypothesize that: (1) a 5-factor structure of the BREQ-2 will be found with adequate psychometric properties, adequate internal consistency and nomological validity (e.g., the more autonomous types of behavioural regulation will be associated with greater enjoyment of PE, less social anxiety in PE, and less social and physique anxiety); (2) younger adolescents and boys will show more self-determined forms of autonomous regulation than middle adolescents and girls; and (3) age and sex will moderate the relationship between different types of behaviour regulation in PE and enjoyment of PE.

2. Method

2.1. Participants

The total sample was composed of 666 students enrolled in summer schools at the

Polytechnic University of Valencia, University of Valencia, and secondary schools. The mean age ranged from 10 to 16 years old (*M* = 13.03; *SD* = 1. 90) (51.8% females).

The eligibility criteria were age between 10-16 years old and not having any physical condition that could keep them from practicing PE. Descriptive statistics of different types of behavioural regulation in PE and other psychological constructs related to PE according to age groups (young adolescents:10-13 years old; and middle adolescents: 14-16 years old) and sex are displayed in Table 1.

Table 1. Means and Standard Deviations of the BREQ-2, PACES, PASAS, and SPAS.

	Young adolescents (*n* = 366)		**Middle adolescents** (*n* = 300)	
	Girls (*n* = 188)	Boys (*n* = 178)	Girls (*n* = 157)	Boys (*n* = 143)
BREQ-2				
Intrinsic regulation	4.21 (0.87)	4.36 (0.64)	3.59 (0.96)	3.99 (0.96)
Identified regulation	4.31 (0.71)	4.30 (0.72)	3.88 (0.92)	4.01 (0.96)
Introjected regulation	2.68 (1.06)	2.57 (1.10)	2.52 (1.11)	2.58 (1.17)
External regulation	2.23 (1.11)	2.20 (1.04)	1.85 (0.88)	1.80 (0.80)
Amotivation	1.39 (0.62)	1.45 (0.74)	1.64 (0.76)	1.59 (0.74)
Intrinsic-identified regulation	4.25 (0.76)	4.33 (0.61)	3.65 (0.87)	3.98 (0.92)
Enjoyment (PACES)	29.98 (4.27)	30.85 (3.82)	29.35 (4.02)	31.27 (2.76)
Social anxiety in PE (PASAS)	36.51 (11.40)	33.18 (10.26)	35.82 (13.10)	31.82 (9.62)
Social physique anxiety (SPAS)	36.94 (10.53)	33.31 (8.72)	35.38 (10.20)	29.86 (8.44)

Note. BREQ-2: Behavioral Regulation in Exercise Questionnaire- 2; PASAS: Physical Activity and SportAnxiety Scale; PACES: Physical Activity Enjoyment Scale; SPAS: Social Physique Anxiety Scale; PE: physical exercise.

[a]Due to missing data, PACES, PASAS, and SPAS scores were calculated with 256, 72, and 74 "young adolescents," respectively, and 42, 253, and 244 "middle adolescents" respectively.

2.2. Measures

2.2.1. Behavioural regulation in exercise questionnaire- 2 (BREQ-2) (Markland & Tobin, 2004). Responses are reported on a 5-point scale from 0 (not true for me) to 5 (very true for me). The Spanish version used with the adult population was employed in this study (Moreno-Murcia et al., 2007), in which the following subscales were found: intrinsic regulation (items 4, 10, 15, 18); identified regulation (items 3, 8, 14, 17); introjected regulation (items 2, 7, 13); external regulation (items 1, 6, 11, 16); and amotivation (items 5, 9, 12, 19). Internal consistency ranged from α = .81 to α =. 89 for all subscales. Following the Hambleton and Patsula (1999) recommendations, we carried out a pilot test with 37 adolescents (ranging from 10 to 16 years old) in order to assure that participants understood correctly the instructions and the items of the BREQ-2. Since we verified that all the items were understandable by the adolescents through an in-depth interview after the participants filled in the questionnaire, no changes were made in the questionnaire. Moreover, all the items make sense to be asked in the adolescence period (that is, there is no items that can only be answered in the adulthood). We did not carry out a cultural adaptation because the version that we used was already validated in Spain (Moreno-Murcia et al., 2007).

2.2.2. Physical activity and Sport Anxiety Scale (PASAS) (Norton et al., 2004). It evaluates social anxiety in PE activities. It is composed of 16 items and 2 factors: Social anxiety while playing sports and Social anxiety while exercising. The items are answered on a Likert scale from 1 (not true for me) to 5 (very true for me). Internal consistency for the total scale was α =.73 in Norton et al. (2004). In this study, the internal consistency for the total scale was α = .87.

2.2.3. Physical Activity Enjoyment Scale -Short Version (PACES) (Kendzierski & DeCarlo, 1991). It evaluates enjoyment in the practice of PE with five items (one item was removed because it was not related to the objective of the study), using bipolar adjectives and a 7-point response. The Spanish adaptation (Fernández et al., 2008) showed adequate internal consistency (α = .82). In this study, the internal consistency for the total scale was α = .84.

2.2.4. Social Physique Anxiety in Adolescence (SPAS) (Hart et al., 1989). It measures the degree of anxiety a person experiences when he/she perceives that others are or may be negatively evaluating his/her physique. It is composed of 12 items and 2 factors: physique presentation discomfort and negative physique evaluation concerns. Items are scored on a 5-point Likert scale from 0 (not at all) to 5 (extremely characteristic of me). Regarding the psychometric properties, the SPAS showed high internal consistency (α = .90) in Hart et al. (1989). In this study, the internal consistency for the total scale was α = .82.

2.3. Procedure

Participants were informed about the study, and their parents signed informed consent documents before the adolescents filled out the questionnaires. This study was approved by the Ethical Committee of the University of Valencia. The students completed the measures in a classroom setting supervised by research assistants who were available to answer questions. The approximate time required to complete the instruments was 35 minutes.

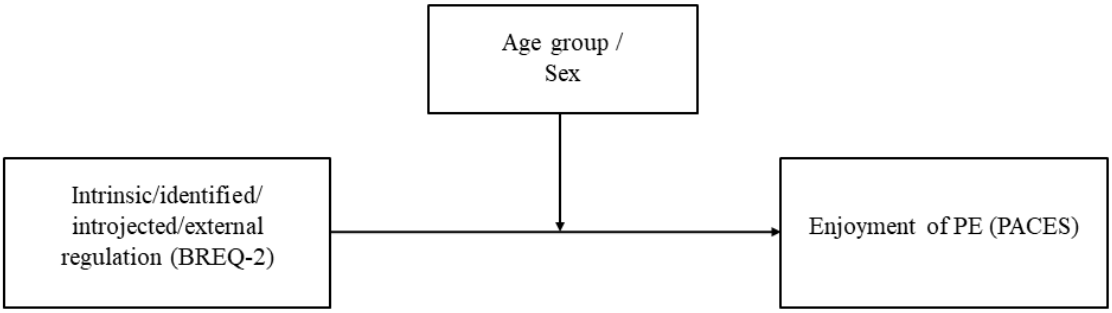
2.4. Data analyses

Statistical analyses were conducted using JASP v0.10.2 (2019) and the SPSS v.26. Missing item values were imputed using the Expectation–Maximization Algorithm method. The sample's normality was analysed, verifying that skewness values were ≤|2|, and kurtosis values were ≤|7| (West et al., 1995). Firstly, Confirmatory Factor Analysis (CFA) was performed to analyse the psychometric properties of the BREQ-2, with a five-factor structure. Due to the non-normality of the data, the maximum likelihood with robust correction method was used (Satorra & Bentler, 1994). Several fit criteria were assessed using the recommended cut-offs by the literature (Abad et al., 2011): (1) Chi square statistic ($p \geq .05$); (2) Comparative Fit Index (CFI ≥ .90, ideally ≥ .95); (3) Tucker-Lewis Fit Index (TLI ≥ .90, ideally ≥ .95); (4) the Root Mean Square Error of Approximation (RMSEA ≤ 0.06); (5) Goodness of Fit Index (GFI between 0 and 1, ideally

≥.95); (6) Standardized Root Mean Square Residual (SRMR ≤ 0.08). Following the recommendations by Hu and Bentler (1999), a combination of the CFI ≥ .95, SRMR ≤ 0.08, RMSEA ≤ 0.06 was used to determine the good fit between the model and the data. Secondly, internal consistency of the BREQ-2 was assessed using Cronbach's alpha coefficient. Finally, nomological validity was tested, which is a form of construct validity defined as the degree to which a construct behaves as it should within a system of related constructs called a nomological network (Campbell, 1960). We tested the nomological validity of the subscales of the BREQ-2 according to the SDT (Deci & Ryan, 1985; 2000; 2007), and the relationships found in the literature between motivation, enjoyment and anxiety previously introduced (e.g., Thogersen-Ntoumani & Ntoumanis, 2006; Zhang, 2009; Sánchez-Oliva et al., 2014; Sicilia et al., 2014) through Pearson's correlations.

Secondly, to assess the difference in behaviour regulation in PE based on age group and gender, five 2x2 ANOVAs with age (young adolescents -10-13 years old-; and middle adolescents -14-16 years old) and sex (girls and boys) as between-factors were performed. When a significant interaction was found, post-hoc analyses using Bonferroni adjustment were conducted. Finally, moderation analyses were carried out to examine whether the relationships between intrinsic/introjected/identified/external regulation and the enjoyment of PE were moderated by the sex or the age group (see Figure 1). The procedure described by Hayes (2013) was performed using the PROCESS macro for SPSS. Significance tests (p < .05) or a confidence interval (not including zero) for the interaction answered the question. Regression coefficients are reported in unstandardized form as *b*-values. Conditional effects of intrinsic/introjected/identified/external regulation on enjoyment of PE at the two moderator values were estimated with the "pick-a-point" approach.

Figure 1. Diagram of Moderations of the Intrinsic/Identified/Introjected/External Regulation on Enjoyment of PE by Age Group and Sex.



Note. BREQ-2 = Behavioural regulation in exercise questionnaire- 2; PACES = Physical Activity Enjoyment Scale; PE = Physical activity.

3. Results

3.1. Psychometric Structure and Internal Consistency of the BREQ-2

Random missing values percentage ranged from 0 to 3.5 % per item. Descriptive statistics for all the BREQ-2 items are shown in Table 2. Fit indices from the CFA indicated an adequate fit with a 5-factor structure: χ^2 (142) = 530.831, p < .001; CFI = 0.895; TLI = 0.874; RMSEA = 0.064, 90% CI [0.058, 0.070]; GFI = 0.987; SRMR = 0.062. However, the CFA with the 5-factor structure was performed without item 17 due its low factor loading (< .40), and the empirical data showed a good fit to the theoretical model: χ^2 (125) = 389.946, p < .001; CFI = 0.926; TLI = 0.909; GFI = 0.991; RMSEA = 0.056, 90% CI [0.050, 0.063]; GFI = 0.991; SRMR = 0.047. Standardized factor loadings of the BREQ-2 items were all significant (*p's* < .001) and ranged from .512 to .833 (see Table 2 and Figure 2). Cronbach's alpha values were: intrinsic regulation (α = .823), identified regulation, (α = .670), introjected regulation (α = .695), external regulation (α = .755), and amotivation (α = .672).

As the internal consistency was questionable for 2 subscales, an Exploratory Factor Analysis (EFA) was conducted. Kaiser-Meyer-Olkin (KMO = 0.84) and the Barlett's Test of

Sphericity value, χ^2 (171) = 3834.80, $p < .001$, revealed that the data was appropriate to perform a factor analysis. The Parallel Analysis (Horn, 1965) determined that 4 factors should be retained, with the following fit indices: $\chi^2(101) = 274.939$, $p < .001$; TLI = 0.919; RMSEA = 0.051, 90% CI [0.044-0.058]. The factorial rotation with four factors was carried out using an oblique –and specifically, oblimin– method. All the item communalities had values above 0.30. The standardized factor loadings of item 3, 11 and 17 were relatively low and/or showed cross-loadings on multiple factors (item 3 in intrinsic-identified regulation = .310; item 11 in external regulation and amotivation = .414 and .363, respectively; and item 17 in introjected regulation and amotivation = .397 and .303, respectively), but the rest of the items ranged from .418 to .843 (see Table 2 and Figure 2).

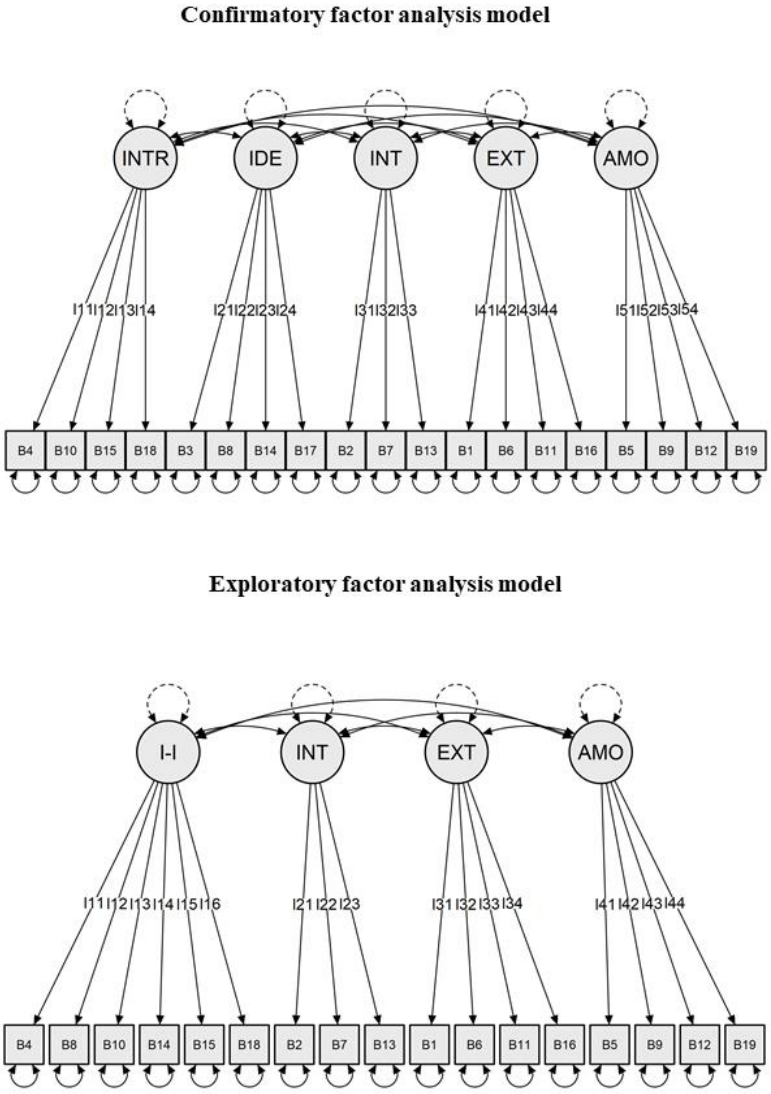
Another EFA was carried out removing 3 and 17 items, as the "if-item-deleted alpha" showed that the Cronbach alphas increased if items 3 and 17 were deleted (in the case of item 3 in introjected-identified regulation from $\alpha = .841$ to $\alpha = .843$; and in the case of item 17 in introjected regulation from $\alpha = .690$ to $\alpha = .695$, and in amotivation from $\alpha = .599$ to $\alpha = .672$). Again, a model with 4 dimensions emerged with the following fit indices: $\chi^2(74) = 227.707$, $p < .001$, TLI = 0.915; RMSEA = 0.056, 90% CI [0.048-0.064]. Introjected, amotivation, and external subscales were maintained, but intrinsic and identified subscales loaded in the same factor. The internal consistency of the new factor (intrinsic-identified regulation) was $\alpha = .841$.

Table 2. Psychometric Properties of the BREQ-2.

	Skewness Index	Kurtosis Index	*M (SD)*	CFA λ_1	CFA λ_2	CFA λ_3	CFA λ_4	CFA λ_5	AFE λ_1	AFE λ_2	AFE λ_3	AFE λ_4
Item 1	0.80	-0.80	2.21 (1.44)				.77				.77	
Item 2	0.50	-1.09	2.38 (1.40)			.59				.57		
Item 3	-1.46	1.54	4.23 (1.06)		.52				.31			
Item 4	-1.32	0.98	4.11 (1.14)	.64					.68			
Item 5	1.66	1.71	1.66 (1.13)					.51				.42
Item 6	0.57	-1.07	2.39 (1.43)				.82				.82	
Item 7	0.10	-1.33	2.80 (1.44)			.69				.68		
Item 8	-1.09	0.45	4.03 (1.13)		.75				.57			
Item 9	1.74	1.99	1.64 (1.14)					.52				.51
Item10	-1.14	0.66	4.04 (1.12)	.72					.69			
Item 11	1.18	0.22	1.88 (1.22)				.51				.41	.36
Item 12	2.37	4.99	1.42 (0.93)					.71				.68
Item 13	0.29	-1.15	2.60 (1.38)			.69				.69		
Item 14	-1.31	1.16	4.17 (1.07)		.66				.44			
Item 15	-1.29	1.14	4.19 (1.03)	.83					.84			
Item 16	1.57	1.50	1.69 (1.12)				.53				.47	
Item 17	0.87	-0.45	2.08 (1.28)		.17					.40		.30
Item 18	-0.91	-0.01	3.88 (1.19)	.75					.73			
Item 19	3.07	9.24	1.31 (0.83)					.65				.55

Note. λ = Factorial loadings; CFAλ1 = Intrinsic Regulation; CFAλ2 = Identified Regulation; CFAλ3 = Introjected Regulation; CFAλ4 = External Regulation; CFAλ5 = Amotivation; AFEλ1 = Intrinsic-Identified Regulation; AFEλ2 = Introjected Regulation; AFEλ3 = External Regulation; AFEλ4 = Amotivation. CFA = Confirmatory Factor Analysis; EFA = Exploratory Factor Analysis.

Figure 2. Confirmatory and Exploratory Factor Models Tested for the BREQ-2.



Note. INTRI = Intrinsic regulation; IDE = Identified regulation; INT = Introjected regulation; EXT = External regulation; AMO = Amotivation; I-I: Intrinsic-Identified regulation; B = BREQ-2 Item.

3.2. Nomological Validity of the BREQ-2

Pearson's correlations were performed between the types of behavioural regulation in PE (plus the new factor that arose with the EFA) and related constructs (i.e., enjoyment of PE, social anxiety in PE, and social physique anxiety) (see Table 3).

Regarding the inter-correlation between the types the behavioural regulation in PE, those that were closer in the continuum of the SDT were positively correlated: intrinsic and identified regulation; identified and introjected regulation; introjected and external regulation; and external regulation and amotivation. Moreover, the extremes of the continuum were negatively correlated: intrinsic and external regulation, intrinsic regulation and amotivation; and identified regulation and amotivation (although identified and external regulation did not achieve significance). The factor intrinsic-identified regulation was positively correlated with introjected regulation and negatively correlated with external regulation and amotivation.

As regards the relationship with enjoyment and anxiety in PE, intrinsic and identified regulation were correlated positively with enjoyment, but negatively with social anxiety in PE and social physique anxiety. At the contrary, external regulation and amotivation were negatively correlated with enjoyment, but positively with social anxiety in PE and social physique anxiety. Similarly, introjected correlation was positively correlated with social anxiety in PE and social physique anxiety, but not with enjoyment.

Table 3. Pearson Correlations Between BREQ-2, PACES, PASAS, and SPAS.

	Intrinsic regulation	Identified regulation	Introjected regulation	External regulation	Amotivation	Intrinsic-identified regulation
Identified regulation (BREQ-2)	.61**					
Introjected regulation (BREQ-2)	.05	.25**				
External regulation (BREQ-2)	-.10*	-.07	.29**			
Amotivation (BREQ-2)	-.39**	-.41**	.03	.28**		
Intrinsic-identified regulation (BREQ-2)	.95**	.80**	.12**	-.09*	-.43**	
Enjoyment of PE (PACES)	.40**	.22**	.02	-.14*	-.19**	.39**
Physical activity anxiety (PASAS)	-.34**	-.18**	.22**	.28**	.25**	-.31**
Social Physique anxiety (SPAS)	-.24**	-.19**	.18**	.24**	.14*	-.24**

Note. *$p < .05$; ** $p < .01$. BREQ-2 = Behavioural regulation in exercise questionnaire- 2; PASAS = Physical activity and Sport Anxiety Scale; PACES = Physical Activity Enjoyment Scale; SPAS = Social Physique Anxiety Scale; PE = Physical Exercise.

3.3. Differences in BREQ-2 by age group and sex

Intrinsic regulation

There was a main effect of age group on intrinsic regulation, $F(1,662) = 53.05$, $p < .001$, $\eta^2_p = .07$, and a main effect of sex on intrinsic regulation, $F(1,662) = 16.94$, $p < .001$, $\eta^2_p = .03$. However, the interaction between age group and sex was marginally significant, $F(1,662) = 3.37$, $p = .067$, $\eta^2_p = .01$. Pairwise comparisons indicated that young adolescents showed more intrinsic regulation in PE than middle adolescents ($p < .001$), and boys showed more intrinsic regulation in PE than girls ($p < .001$) (see Table 1).

Identified regulation

There was a main effect of age group on identified regulation, $F(1,662) = 30.67$, $p < .001$, $\eta^2_p = .04$, but no main effect of sex on identified regulation, $F(1,662) = 0.77$, $p = .382$, $\eta^2_p = .00$, and no interaction between age group and sex, $F(1,662) = 1.30$, $p = .255$, $\eta^2_p = .00$. Pairwise comparisons indicated that young adolescents showed more identified regulation in PE than middle adolescents ($p < .001$).

Introjected regulation

There was no main effect of age group on introjected regulation, $F(1,662) = 0.76$, $p = .384$, $\eta^2_p = .00$, no main effect of sex on introjected regulation, $F(1,662) = 0.09$, $p = .765$, $\eta^2_p = .00$, or of the interaction between age group and sex, $F(1,662) = 1.13$, $p = .288$, $\eta^2_p = .00$.

External regulation

There was a main effect of age group on external regulation, $F(1,662) = 26.40$, $p < .001$, $\eta^2_p = .04$, but there was no main effect of sex on external regulation, $F(1,662) = 0.35$, $p = .553$, $\eta^2_p = .00$, or of the interaction between age group and sex, $F(1,662) = 0.02$, $p = .877$, $\eta^2_p = .00$. Pairwise comparisons indicated that young adolescents showed more external regulation in PE

than middle adolescents ($p < .001$).

Amotivation

There was a main effect of age group on amotivation, $F(1,662) = 11.98$, $p < .001$, $\eta^2_p = .02$, but there was no main effect of sex on amotivation, $F(1,662) = 0.12$, $p = .912$, $\eta^2_p = .00$, or of the interaction between age group and sex, $F(1, 662) = 1.07$, $p = .301$, $\eta^2_p = .00$. Pairwise comparisons indicated that young adolescents showed less amotivation in PE than middle adolescents ($p < .001$).

Intrinsic-identified regulation

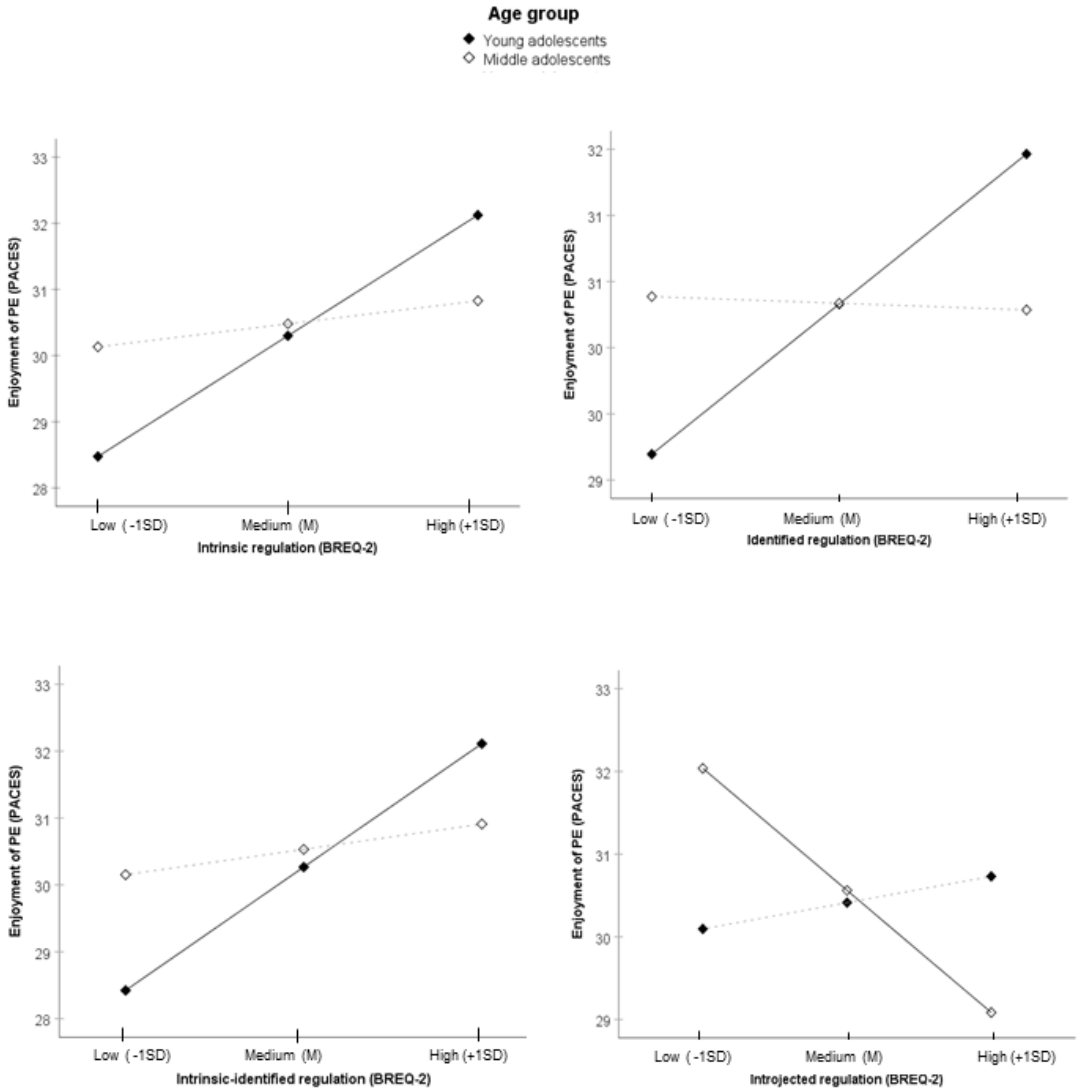
There was a main effect of age group on intrinsic-identified regulation, $F(1,662) = 59.80$, $p < .001$, $\eta^2_p = .08$, and a main effect of sex on intrinsic-identified regulation, $F(1,662) = 11.38$, $p < .001$, $\eta^2_p = .02$. The interaction between age group and sex was also significant, $F(1,662) = 4.10$, $p = .043$, $\eta^2_p = .01$. Pairwise comparisons indicated that boys showed more intrinsic-identified regulation in PE than girls ($p < .001$), and young adolescents showed more intrinsic-identified regulation in PE than middle adolescents ($p < .001$). However, an interaction effect showed that in the middle adolescence, boys showed significantly more intrinsic-identified regulation in PE than girls ($p < .001$).

3.4. Moderation of the effect of the intrinsic/ identified/ introjected/ external regulation on enjoyment of PE by age group and sex

The interactions between age group and intrinsic/identified/introjected regulation were significant, $F(1,294) = 5.64$, $p = .018$, $F(1,294) = 4.35$, $p = .038$, and $F(1,294) = 10.20$, $p = .002$, accounting for about 1.62%, 1.40%, and 2.24% of the variance in the enjoyment of PE, respectively (see Figure 3). Hence, the age group moderated the effect of the intrinsic/identified/introjected regulation on enjoyment of PE. Analysis of simple slopes showed

that in young adolescents, there were positive significant relationships between intrinsic regulation and enjoyment of PE, b = 2.68, 95% CI [01.71, 3.64], t = 5.44, p < .001; and between identified regulation and enjoyment of PE, b = 1.66, 95% CI [0.80, 2.52], t = 3.81, p < .001. However, in middle adolescents, there was a negative significant relationship between introjected regulation and enjoyment of PE, b = -1.40, 95% CI [-2.35, -0.45], t = -2.91, p = .004. Intrinsic-identified regulation was also tested, and an interaction between age group and this factor was also significant, F(1, 294) = 6.46, p = .012, accounting for 1.87% of the variance in the enjoyment of PE. A positive significant relationship between intrinsic-identified regulation and enjoyment of PE was found, b = 3.04, 95% CI [1.99, 4.09], t = 5.70, p < .001. Non-significant interactions were found between age group and external regulation, or sex and the different types of regulation in PE (*p's* > .05).

Figure 3. Simple Slopes Graph of the Regressions of Intrinsic/Identified/Introjected/External Regulation on Enjoyment of PE at Two Levels of Age Group (Young and Middle Adolescents).



Note. "Low", "medium" and "high" levels of the moderators represent the mean and ± 1 standard deviation (SD) (Intrinsic regulation: 4.33 ± 0.68; Identified regulation: 4.34 ± 0.68; Introjected regulation: 2.64 ± 1.06; Intrinsic-identified regulation: 4.33 ± 0.60) (calculated from the entire sample, centering the mean). Continuous black line represents the category of the age group in which the conditional effect of "the intrinsic/introjected/external regulation" on "enjoyment of PE" is significant. BREQ-2 = Behavioural regulation in exercise questionnaire- 2; PACES = Physical Activity Enjoyment Scale; PE = Physical activity.

4. Discussion

The objectives of this study were, first, to confirm the existence of five levels of motivation toward PE in adolescent population; second, to assess the differences between sex and age group on the different types of behaviour regulation in PE; and, finally, to analyse whether the age group and sex could moderate the relationship between the different types of behavioural regulation in PE and enjoyment.

Results of the CFA of the BREQ-2 supports the existence of a five-factor structure with adequate internal consistency for all the types of behavioural regulation in PE, as in other studies (Markland & Tobin, 2004; Moreno-Murcia et al., 2007; Farmanbar et al., 2011; Verloigne et al., 2011; Crăciun & Rus, 2012; Liu et al., 2015). Moreover, item 17 ("*I get restless if I don't exercise regularly*") was removed due to its low factor loading, as occurred in other validation studies (Moreno-Murcia et al., 2007; Liu et al., 2015; Chen et al., 2018). Nevertheless, as the internal consistency was questionable for identified and introjected regulation, we additionally performed an EFA, in which item 17 (and, also item 3 *"Because I value the benefits of exercise"*) had again low factor loadings and cross-loadings on multiple factors. Moreover, a 4-factor structure emerged in the EFA: introjected regulation, external regulation, and amotivation were maintained, as occurs in other validations carried out in Belgian (Verloigne et al., 2011) and Romanian (Crăciun & Rus, 2012) adolescents; but items of intrinsic and identified regulation loaded in the same factor with high internal consistency. This unique intrinsic-identified regulation had an adequate nomological validity, as it was positively correlated with introjected regulation, but negatively correlated with external regulation and amotivation. This factor combining both types of regulation in a unique autonomous form of regulation was also found in a validation carried out in Chinese adolescents (Chen et al., 2018). Autonomous motivation −together with controlled motivation− constitutes a central distinction in SDT, in which individuals are identified with the value of the PE and integrate it into their sense of self (Deci & Ryan, 2008). Considering the cultural distance between Chinese and Spanish adolescents,

findings point out that maybe it is not worth it to distinguish between intrinsic and identified in adolescents. Moreover, item 17 belongs to identified regulation, which has been a consistent problematic item through several BREQ-2 validations in different languages. For this reason, considering a single factor of autonomous motivation, removing item 17 (and item 3 if this low loading is replicated in future studies) could be a more parsimonious approach for assessing autonomous regulation in PE. Therefore, the first study hypothesis regarding the 5-factor structure of the BREQ-2 was partially supported.

Regarding the nomological validity of the BREQ-2, correlations between the types of regulations in PE close in the continuum were positively correlated, while they were negatively correlated with those at the opposite in the continuum. Furthermore, the correlations of the BREQ-2 with enjoyment, social anxiety in PE, and social physique anxiety were in the expected direction. On the one hand, social anxiety in PE and social physique anxiety were negatively correlated with the more self-determined forms of regulation (e.g., intrinsic and identified regulation), whereas they were positively correlated with the more external forms of regulation (i.e., introjected and external regulation) and amotivation. On the other hand, enjoyment of PE was positively correlated with the more self-determined forms of regulation, and negatively correlated with external regulation and amotivation. These results agree with other studies that found that positive affective responses to PE are positively associated with intrinsic regulation and self-determined forms of extrinsic regulation in PE (Thogersen-Ntoumani & Ntoumanis, 2006; Edmunds et al., 2008; Zhang, 2009; Sánchez-Oliva et al., 2014; Sicilia et al., 2014). Therefore, interventions aimed at increasing PE should encourage and strengthen self-determined types of regulation of PE in order to increase enjoyment and decrease social anxiety related to PE. This is especially relevant because some of these constructs (e.g., enjoyment, social anxiety related to the physical appearance) are the main reason for not achieving the minimum levels of PE (Babic et al., 2014; Lewis et al., 2014), especially in girls (Robbins et al., 2003; Portela-Pino et al., 2020).

Regarding the differences in the types of PE regulation strategies based on age and sex, on the one hand, young adolescents showed more intrinsic, identified, and external motivation than middle adolescents. Conversely, middle adolescents showed more amotivation than young adolescents. On the other hand, boys showed more intrinsic motivation than girls. In fact, an interaction effect between sex and age group showed that even in the middle adolescence (in the period that the intrinsic-identified regulation tends to be lower than in young adolescence), boys show more intrinsic-identified regulation than girls. Some studies (e.g., Butt et al., 2011) have already found that men were more motivated by intrinsic factors, whereas women were motivated by extrinsic factors. Hence, the second hypothesis was supported, except that external motivation was higher in young adolescents than in middle adolescents. It seems that young adolescents have a wide range of ways to regulate their PE. This make sense within the SDT, which is not conceptualized as a developmental continuum or a stage model, as each individual can have different levels of multiple motivations or goals acting concurrently (Deci & Ryan, 1985; 2000). Therefore, young adolescents could have more motives to be active than older adolescents.

In addition, our third hypothesis was partially supported, as only age moderated the relationship between behavioural regulation and enjoyment of PE. Moderation analyses showed that enhancing some types of regulation in PE in young or middle adolescents has different effects on enjoyment of PE. Results pointed out that the effects of intrinsic/identified/introjected regulation on enjoyment of PE depended on age. In young adolescents, more intrinsic and identified regulation was related to more enjoyment of PE. However, in middle adolescents, more introjected regulation was related to less enjoyment of PE. Future interventions aimed at increasing motivation toward PE should take the age of the adolescents into account in trying to increase enjoyment. In younger adolescents, interventions could be focused on enhancing intrinsic and identified regulation in PE, whereas in middle adolescents, interventions should avoid enhancing introjected regulation.

Some limitations of the current study should be noted. The age range of the sample is narrowed, so the findings are not generalizable for all the adolescent population. The results are only generalizable to a specific cultural circle: girls and boys between 10 and 16 years old, who are students of high schools placed in a large metropolitan area of Valencia. A larger population covering all the adolescent period (e.g., from 10 to 19 years old) and different cultural contexts could have been interviewed in order to increase the generalizability of the results. Moreover, another limitation is that we have some missing data due to some adolescents did not answer all the questionnaires.

In conclusion, the BREQ-2 questionnaire supports the existence of a five-factor structure for the types of behavioural regulation in PE in adolescent population. Nevertheless, a 4-factor structure with a single intrinsic-identified regulation with an adequate adjustment also emerged. In addition, this study has demonstrated that the different types of PE regulation fluctuate depending on age and sex. Furthermore, this study shows that the more self-determined types of regulation are positively associated with psychological constructs related to the practice of PE. Finally, this study highlights the importance of fostering specific types of behaviour regulation to increase enjoyment depending on age in order to develop PE interventions.

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CHAPTER 3. Study 2

The influence of success or failure in the practice of physical activity in children: Manipulating the outcome in a virtual reality task

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This chapter is currently under review as: Navarro, J., Cebolla, A., & Baños, R.M. The influence of success or failure in the practice of physical activity in children: Manipulating the outcome in a virtual reality task.

Abstract

The purposes of this study were to manipulate the outcomes on physical activity (PA) task, and analyze its effects on several variables (subjective tiredness, affect, arousal, speed, and heart rate), and to exploring the moderation role of self-efficacy and motivation. Thirty children were asked to run 1 kilometer in a virtual environment and try to beat their opponents. Participants were randomized in two conditions: "Success Experience Condition", participants' avatars always win, and "Failure Experience Condition", participants' avatars always lose. Subjective tiredness, affect, arousal, speed and heart rate were taken in five times. In Success Experience Condition, the participants showed progressively higher scores for positive affect, arousal and speed. In addition, high expectations of ability or competence toward PA were related to greater arousal, and higher intrinsic motivation was related to greater speed. In Failure Experience Condition, lower amotivation was related to higher arousal. This study shows the efficacy of a virtual reality scenario in manipulating feedback received during a PA task and, its influence on physical activity responses.

Keywords: physical activity; manipulation; outcomes; virtual reality; children.

1. Introduction

The health benefits of physical activity (PA) are well recognized in fields such as overweight prevention (Barlow, 2007), helping young people to develop healthy musculoskeletal (Gunter et al., 2012), metabolic systems (Janssen & Leblanc, 2010), or preventing cardiovascular problems (Kriemler et al., 2011). PA has also been associated with multiple psychological benefits (Biddle & Asare, 2011).

According to the World Health Organization (WHO, 2010), young people should accumulate at least 60 minutes of moderate to high intensity PA every day. However, evidence suggests that less than 20% of children globally meet public health guidelines (Martin & Murtagh, 2015), and 80% do not reach the minimum recommended levels of PA in Europe (Kahlmeier, 2015). For these reasons, increasing PA levels in children is particularly important (Waring et al., 2007).

Most interventions designed to increase PA have focused on cognitive (McAuley & Blissmer, 2000), social (Brassington et al., 2002) and environmental processes (Trost et al., 2002). However, the literature shows that affective processes are also positively related to the PA (Ekkekakis, 2003; Ekkekakis et al., 2005; Ekkekakis & Lind, 2006; Ekkekakis et al., 2008; Magnan et al., 2013; Brand & Ekkekakis, 2018). Positive affect experienced during PA can improve PA performance and reduce perceived effort (McCarthy, 2015). For all these reasons, it would be relevant to take this variable into account when developing interventions aimed at increasing and improving the PA in children.

Virtual reality (VR) has shown to be a useful tool for influencing beliefs and behaviors related to PA (Krause & Benavidez, 2014; Song et al., 2011) and therefore, for preventing or treating physical inactivity in children (Kiefer et al., 2017). Recent studies have concluded that VR scenarios, and more specifically active video games (electronic games that allow players to physically interact by using body movements with images on a screen) can increase PA in children and improve their body composition (Lisón et al., 2015; Martí et al., 2015).

VR scenarios have the potential to influence physiological and psychological variables related to PA, such as heart rate (Tan et al., 2002), energy expenditures (Lanningham-Foster et al., 2006), and minutes of practice (Fogel et al., 2010). In addition, it has been shown to increase players' self-esteem, motivation (Krause & Benavidez, 2014).

According to Krause and Benavidez (2014), VR scenarios may create success experiences during PA. Successful experiences may increase self-confidence, positive affect, and consequently improve the PA. In addition, VR scenarios can create a "sense of first-hand of success experiences", being not an observer, but an "agent" of the experience. For example, they provide the user the opportunity to become the main character in a video game, and the user´s body and movements can be projected onto the screen in real time. VR scenarios can also offer the opportunity to receive social persuasion and provide feedback about the user´s performance during the game (Krause & Benavidez, 2014).

Recent evidence suggests that individuals who embody an avatar (virtual representation of the person) in a VR experience, tend to self-attribute the execution of their avatar to themselves. Therefore, if the execution of the avatar is good, individuals infer that they are doing well (Debarda, 2018). The execution and outcomes performance of the avatars can be manipulated through VR. It has been suggested that feedback manipulation during PA can positively influence the individual's experience and performance (Strohacker et al., 2013).

Although VR is gaining popularity in the PA contexts, more research is needed to show if virtual manipulations on PA performance in children could be effective in improving their PA practice.

The objectives of this study are to manipulate the outcomes on a PA task using a VR scenario, and analyze its effects on PA variables (subjective tiredness, affect, arousal, speed, and heart rate), comparing two conditions: the "Success Experience Condition" (SEC: participants' avatars always win), and the "Failure Experience Condition" (FEC: participants' avatars always lose). In addition, we explore whether participant´s self-efficacy expectations and dispositional

motivation moderate the relationship between the condition and the effects on PA responses. We hypothesize that SEC participants will show higher scores on positive affect, arousal, speed, and heart rate, and lower scores on subjective tiredness, as they progress through the PA task, compared to the FEC participants.

2. Method

2.1. Participants

The total sample was composed of 30 children (*M* = 10.77; *SD* = 1.77) (17 females). The eligibility criteria were age (7-14 years old) and not having any physical condition that could prevent them from PA. Participants were informed about the study, and their parents signed informed consent documents. The mean body mass index (BMI) was 22.79 (*SD* = 9.33). This study was approved by the Ethical Committee of the University of Valencia.

2.2. Measures and Materials

2.2.1. Anthropometric and sociodemographic data. Participants' age, sex, height and weight were collected using a questionnaire and a TANITA BC-420.

2.2.2. Behavioral Regulation in Exercise Questionnaire (BREQ-2) (Markland & Tobin, 2004). This questionnaire consists of 19 items measuring stages on the continuum of self-determination. It measures external regulation, introjected regulation, identified regulation, and intrinsic regulation, and it adds amotivation on a scale from 0 (Not at all true for me) to 5 (absolutely true for me). Internal consistency ranged from α = .81 to α =. 89 for all subscales (Murcia et al., 2007).

2.2.3. Self-efficacy questionnaire (Aedo & Ávila, 2009). It is designed to evaluate self-efficacy toward PA. It is composed of 16 items divided into three factors: search for positive alternatives to PA, ability to face possible barriers to doing it, and expectations about one´s

ability or competence. The items are answered on a dichotomous scale (yes/no). Internal consistency for the scale was α=73, and the test-retest reliability coefficient was α= 87.

2.2.4. Feeling Scale (FS) (Hardy & Rejeski, 1989). It assesses affective responses during PA. It is a single-item scale on which participants verbally responded to the question, "How do you feel at the moment? in a range from +5 (I feel very good) to −5 (I feel very bad). The FS has been used in several previous exercise studies, and it has shown satisfactory convergent and discriminant validity (Backhouse et al., 2007).

2.2.5 Arousal Scale (AS) (Mehrabian & Russell, 1974). This is a non- verbal pictorial assessment technique that measures the pleasure, arousal, and dominance associated with a person´s affective reaction to a wide variety of stimuli. It consists of a visual analogue scale ranging from 1 (very calm) to 5 (strongly activated). The participants answered it verbally. Bakker et al. (2014) reviewed the scale and supported its usefulness.

2.2.6. Scale of Subjective Perception of Effort (EPSE) (Eston et al., 2000). This is a single-item visual analogue-scale that assesses subjective tiredness in children. It consists of an image where each step represents a different perception of effort. The participant identifies and indicates verbally his/her perception while doing PA. Several studies suggest that it is a valid and reliable scale for children between 7 and 11 years old (Parfitt et al., 2007).

2.2.7. Zephyr HxM Bluetooth heart rate monitor*.* It is a fitness-tracking device supported by both Android and Windows Phone 8 devices. It helps to check the heart rate, distance travelled, speed and intensity level of the workout, using a soft, elastic and adjustable strap worn around the chest.

2.3. Procedure

Participants were individually called to the laboratory for 40 minutes. Prior to the experiment, participants were randomly assigned to one of the two conditions (SEC: 12; FEC: 18). First, anthropometric and sociodemographic data were collected. Then participants

completed questionnaires about motivation and self-efficacy toward PA. Finally, they performed the PA task.

SEC participants were told that their "virtual" opponents were very fast and that the race was very difficult, but they should have to work hard and try to win. The program was manipulated so that participants were ahead of all their opponents and eventually won the race, regardless of their actual performance. FEC participants were told that their "virtual" opponents were very slow and that the race was very easy to win. The program was manipulated so that participants were behind all their opponents and eventually lost the race, regardless of their actual performance.

During the race, every 250 meters, subjective tiredness, affect, arousal, speed, and heart rate were measured. When the race ended, participants were asked about the outcome of the race ("*Did you win or lose the race?*") and the reason for their success or failure *("Why do you think you won (or lost)?").* Participants who discovered the objective of the study were excluded.

Regarding the VR scenario, it represents a virtual race outdoors, a natural landscape, and a finish line. Participants are represented by an avatar (of the same sex) while they run in the virtual race. The participant runs at room in the laboratory, and his or her avatar represents this movement. In addition, there are other runners in the race. The avatars' participants and virtual opponents wear sports clothes. All runners are located at the starting line, and the race ends when the competitor reaches the finish line. While running, participants can see if they are ahead of their virtual opponents or behind them. They can also see their heart rate and speed on the screen.

2.4. Data analyses

The items' missing values were imputed using the Expectation-Maximization method. Differences in subjective tiredness, affect, arousal, heart rate and speed were analyzed through 2 (SEC versus FEC) × 4 (four assessment moments) mixed ANCOVAs, using baseline scores as

covariates. When effects were significant, pairwise comparisons with Bonferroni corrections were performed. Moderation analyses were carried out with each sub-scale scores on the instruments to examine whether the results found for subjective tiredness, affect, arousal, heart rate and speed were moderated by self-efficacy scores and initial motivation (BREQ scores). The procedure described by Hayes (2013) was performed using the PROCESS macro for SPSS. Significance tests ($p < .05$) or a confidence interval (not including zero) for the interaction answered the question. Statistical analyses were conducted using the SPSS for Windows (version 22).

3. Results

3.1. Differences between conditions in PA variables

Descriptive statistics for subjective tiredness, affect, arousal, heart rate and speed are shown in table 1, and ANCOVA results appear in table 2. For subjective tiredness and heart rate (see Figure 1), no significant effects were found. However, significant interaction effects were found for positive affect ($p = .024$), arousal ($p = .043$), and speed ($p = .011$). In the case of positive affect, pairwise comparisons did not show significant differences between the different moments, although a certain tendency was observed because, the positive affect scores of the SEC participants progressively improved (see Figure 1). In the case of arousal, pairwise comparisons showed that the arousal scores of the SEC participants progressively and significantly increased from the first moment to the second ($p = .059$), third ($p = .007$), and fourth ($p = .007$) (see Figure 1). Finally, with regards to speed, pairwise comparisons showed that the speed of the SEC participants increased significantly from the first moment to the fourth moment (.027) (see Figure 1).

Table 1. Descriptive Statistics for Subjective Tiredness, Positive Affect, Arousal, Heart Rate and Speed.

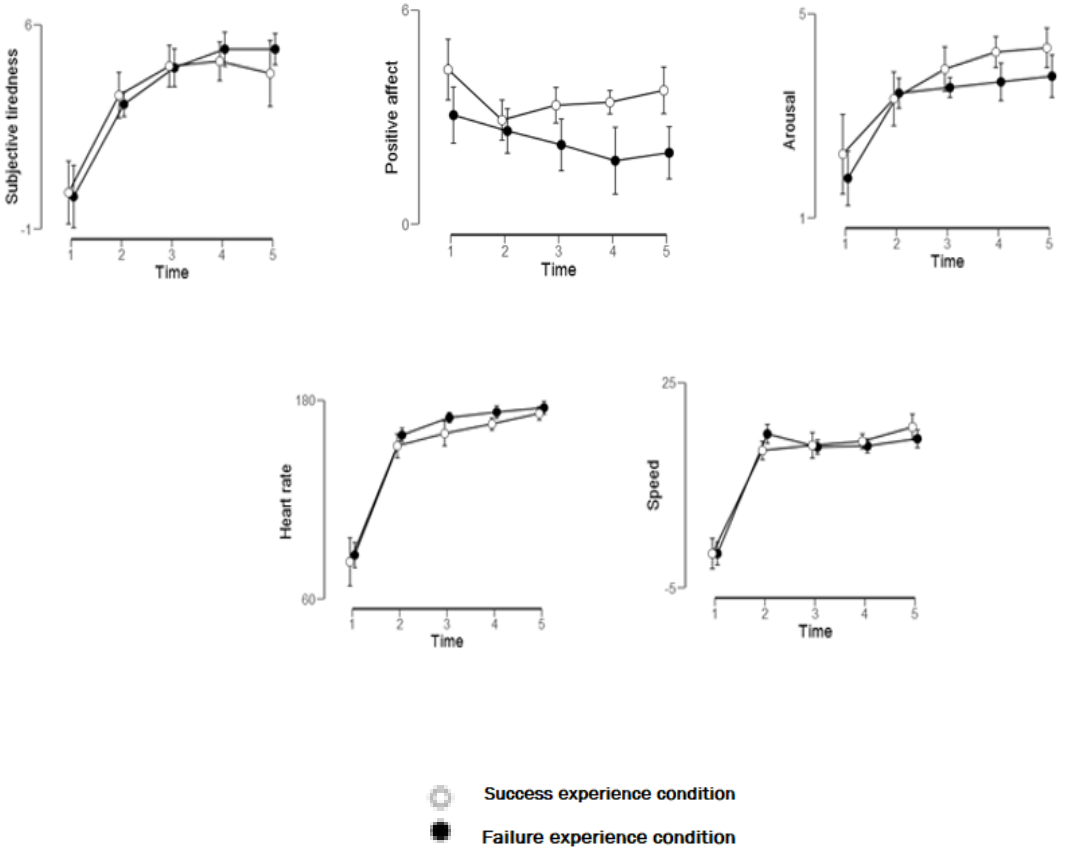
	SEC (*n* = 12)					**FEC(***n* = 18)				
	Baseline	**1st moment**	**2st moment**	**3stmoment**	**4stmoment**	**Baseline**	**1stmoment**	**2stmoment**	**3stmoment**	**4stmoment**
Subjective tiredness	0,25 (0,62)	3,58 (1,78)	4,58 (1,83)	4,75 (2, 18)	4,33 (2,64)	0,11 (0,47)	3,28 (2,22)	4,53 (2,60)	5,17 (2,66)	5,17 (2,38)
Positive affect	4,33 (1,30)	2,92 (1,56)	3,33 (0,89)	3,42 (1,24)	3,75 (1,42)	3,05 (1,95)	2,61 (1,72)	2,22 (1,77)	1,78 (2,49)	2,00 (2,25)
Arousal	2,25 (1,29)	3,33 (1,30)	3,92 (1,08)	4,25 (0,86)	4,33 (0,89)	1,78 (1,00)	3,44 (1,15)	3,55 (0,92)	3,67 (1,08)	3,78 (1,16)
Heart rate	83,28 (15,76)	152,25 (27,55)	161,42 (29,52)	167 (21,42)	172,83 (21,02)	86,53 (12,83)	159,00 (18,27)	169,59 (16,77)	172,88 (16,39)	175,53 (17,18)
Speed	0,00 (0,00)	15,08 (3,78)	15,83 (5,24)	16,41 (3,75)	18,50 (4,79)	0,00 (0,00)	17,50 (3,96)	15,59 (4,20)	15,75 (4,22)	16,80 (4,59)

Note. Abbreviations: SEC = Success experience condition; FEC = Failure experience condition.

Table 2. ANCOVA Results for Subjective Tiredness, Positive Affect, Arousal, Heart Rate and Speed.

	Main effect of Time			Condition x Time effect			Main effect of Condition		
	F	***p*** [a]	η^2_p	***F***	***p*** [a]	η^2_p	***F***	***p*** [a]	η^2_p
Subjective tiredness	*F*(3,78) = 2.14	.102	.08	*F*(3.78) = 1.66	.182	.06	*F*(1,26) = 0.39	.534	.15
Positive affect	*F*(3,78) = 0.03	.994	.00	*F*(3,78) = 3.35	.023	.11	*F*(1,26) = 1.95	.175	.07
Arousal	*F*(3,78) = 2.29	.085	.08	*F*(3,78) = 2.84	.043	.09	*F*(1,26) = 1.35	.256	.05
Heart rate	*F*(3,72) = 1.39	.252	.05	*F*(3,72) = 0.77	.513	.03	*F*(1,24) = 0.32	.571	.01
Speed	*F*(3,81) = 0.66	.252	.58	*F*(3,81) = 3.96	.011	.13	*F*(1,27) = 0.73	.789	.00

Figure 1. Differences Between Conditions in Subjective Tiredness, Positive Affect, Arousal, Heart Rate and Speed.



3.2. Self-efficacy and motivation as moderators

In the case of self-efficacy, moderation analyses (see Table 3) showed that the "expectations of ability or competence toward PA" on the task moderated the change in arousal. The overall model explained 47.88% of the variance, $F(3,26) = 3.89$, $p = .020$. The interaction between condition and self-efficacy towards PA did not include the zero value in the confidence interval, $F(1,26) = 10.38$, $p = .003$, 95% CI [3.65, 4.41], indicating that the expectation of ability or competence toward PA was a moderator of the effect of the condition on Arousal, accounting for 11.40% of the variance. Analyses of simple slopes showed that there was a significant positive relationship between condition and arousal when the expectation of ability or competence toward PA was "higher", $b = -1.26$, 95% CI [-2.26, -0.26], $t = -2.59$, $p = .015$.

Therefore, higher expectations of ability or competence toward PA were related to greater arousal in SEC participants.

In the case of the BREQ subscales, moderation analyses (see Table 3) showed that amotivation toward PA moderated the change in arousal. The overall model explained 47.15% of the variance, $F(3,24) = 9.44$, $p = .000$. The interaction between condition and amotivation did not include the zero value in the confidence interval, $F(1,24) = 10.59$, $p = .003$, 95% CI [3.61 , 4.41], indicating that amotivation toward PA was a moderator of the effect of the condition on Arousal, accounting for 11.26% of variance. Simple slopes analyses showed that there was a positive relationship between condition and arousal when amotivation was "lower", $b = -0.81$, 95% CI [-1.77, 0.15], $t = -1.72$, $p = .097$. However, it did not reach significance. In addition, moderation analyses showed that intrinsic motivation toward the PA task moderated the change in speed. Therefore, lower amotivation was related to greater arousal in FEC participants. In addition, intrinsic motivation toward PA moderated the change in speed. Regarding the intrinsic motivation toward PA, the overall model explained 42.59% of the variance, $F(3,26) = 3.06$, $p = .046$. The interaction between condition and intrinsic motivation did not include the zero value in the confidence interval, $F(1,26) = 5.09$, $p = .032$, 95% CI [15.48, 19.05], indicating that intrinsic motivation toward PA was a moderator of the effect of the condition on speed, accounting for 14.16% of the variance. Analyses of simple slopes showed that there was a significant positive relationship between condition and speed when intrinsic motivation was "higher", $b = -5.03$, 95% CI [-10.13, 0.06], $t = -2.03$, $p = .052$. Therefore, high intrinsic motivation toward PA was related to greater speed in SEC participants.

Table 3. Moderation Analyses.

Moderator variables	Subjetive tiredness	Positive affect	Arousal	Heart rate	Speed
Search for positive alternatives to PA	$F(1,25) = 0.57$, $p = .454$	$F(1,25) = 0.33$, $p = .569$	$F(1,25) = 0.32$, $p = .573$	$F(1,25) = 0.40$, $p = .531$	$F(1,25) = 1.98$, $p = .171$
Ability to face possible barriers to doing it	$F(1,25) = 3.14$, $p = .089$	$F(1,25) = 0.13$, $p = .718$	$F(1,25) = 2.06$, $p = .163$	$F(1,25) = 0.00$, $p = .991$	$F(1,25) = 0.23$, $p = .634$
Expectations of ability or competence	$F(1,26) = 0.16$, $p = .899$	$F(1,26) = 0.00$, $p = .897$	$F(1,26) = 10.38$, $p = .003$	$F(1,26) = 0.69$, $p = .414$	$F(1,26) = 0.05$, $p = .816$
External regulation	$F(1,25) = 0.00$, $p = .960$	$F(1,25) = 0.00$, $p = .986$	$F(1,25) = 0.05$, $p = .822$	$F(1,25) = 0.10$, $p = .749$	$F(1,25) = 0.18$, $p = .670$
Introjected regulation	$F(1,24) = 0.86$, $p = .362$	$F(1,24) = 0.11$, $p = .746$	$F(1,24) = 0.32$, $p = .574$	$F(1,24) = 0.67$, $p = .419$	$F(1,24) = 1.60$, $p = .218$
Identified regulation	$F(1,25) = 0.04$, $p = .834$	$F(1,25) = 1.44$, $p = .241$	$F(1,25) = 1.44$, $p = .241$	$F(1,25) = 0.38$, $p = .540$	$F(1,25) = 0.03$, $p = .855$
Intrinsic regulation	$F(1,26) = 0.75$, $p = .395$	$F(1,26) = 0.13$, $p = .721$	$F(1,26) = 0.19$, $p = .661$	$F(1,26) = 0.29$, $p = .589$	$F(1,26) = 5.09$, $p = .032$
Amotivation	$F(1,24) = 1.12$, $p = .299$	$F(1,24) = 0.74$, $p = .398$	$F(1,24) = 10.59$, $p = .003$	$F(1,24) = 1.43$, $p = .244$	$F(1,24) = 0.06$, $p = .802$

4. Discussion

This study was conducted to manipulate the outcomes on a PA task, using a VR scenario, analyze its effects on several PA responses, and explore the moderation role of self-efficacy expectations and dispositional motivation.

Regarding the first hypothesis, it was partially confirmed because the results did not show an interaction effect (condition x time) for all variables. It was assumed that SEC participants would show higher scores on positive affect, arousal, speed, and heart rate as they progressed through the PA task, and lower scores on subjective tiredness, compared to the FEC participants. Results showed that SEC participants progressively improved their positive affect scores, arousal scores, and speed. However, results did not show significant interaction effects for subjective tiredness and heart rate, although the expected trend was observed.

These results are consistent with other studies that conclude that manipulating feedback received during PA can positively influence performance (Strohacker et al., 2013). In the current study, manipulating the success or failure of a virtual running task, participants who received positive feedback (win versus lose) showed higher positive affect scores, arousal scores, and speed. Therefore, as other research suggests, VR scenarios that create positive and successful experiences can positively influence PA (Krause & Benavidez, 2014), and positive affect experienced during PA can improve PA performance (McCarthy, 2011).

The absence of significant interaction effects in the other variables could be explained by some limitations of the study procedure. It is important to highlight that, although we hypothesized that positive feedback would positively influence the affect during the PA task, and participants' perceptions and physical reactions, this manipulation would have been more potent if the formal feedback were continuous. In our study, even though participants could see if they were ahead or behind their virtual opponents at all times, the results on the PA task were shown only at the end of the race. It would be valuable to study how PA responses could be affected by continuous formal feedback about participants' performance.

As to the moderating role of self-efficacy expectations and dispositional motivation, in the SEC condition, the participants with higher expectations of skill and competence toward PA showed the greatest increases in arousal. Similarly, in the SEC condition, participants with higher intrinsic motivation scores also showed greater speed. In the FEC condition, the participants who scored lower on amotivation toward PA showed greater arousal and involvement in the PA task. These results suggest that, depending on the self-efficacy expectations and dispositional motivation of the users, VR manipulations based on the feedback received can have different effects. When successful experiences are produced, users with the highest expectations of skill and competence and intrinsic motivation toward PA benefit the most. Similarly, when failure experiences are generated, users with less amotivation toward PA benefit the most.

Some limitations of the current study should be pointed out. First, it will be valuable to incorporate new features in the VR scenario. As mentioned above, individuals who embody an avatar in a VR experience, tend to self-attribute the execution of their avatar to themselves (Debarda, 2018). However, greater customization of the avatars in the VR scenarios would lead to greater feelings of identification and imitation (Fox & Bailenson, 2009). Finally, the sample was small and the age range included in the study (7-14 years) represents a developmental range from middle childhood to middle adolescence**.** It would be interesting to limit this wide range to a single developmental stage.

In conclusion, this study shows the efficacy of a VR scenario in manipulating feedback received during a PA task and, consequently, its influence on PA responses. It would be interesting to include this type of manipulation in the VR scenarios that are being developed to improve the PA in children.

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CHAPTER 4. Study 3

The effects of avatar appearance on physical activity: Testing social cognitive theory, proteus effects and goal-gradient predictions on cardiac frequency and step counts

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Abstract

This study tested social cognitive theory and the Proteus effect predictions regarding how avatars can incentivize physical activity (PA). In a 2 x 2 factorial experiment, participants ran while wearing accelerometers and a heart rate monitor. They were randomly assigned to onscreen motion-capturing avatars displaying the participant's face or a stranger's face. Avatars were dressed in sports or formal clothes. Participants showed increased effort as the end goal approached in time, thus revealing goal-gradient effects. As the end goal approached, participants assigned to avatars donning their own face showed increased cardiac frequency compared with those using avatars with a stranger's face. Nearing the end, participants assigned to an avatar with their own face and wearing sports clothes showed increased step counts at a later phase compared with those using avatars with a stranger's face and wearing sports clothes. The results added depth to the temporal dimension of avatar-based interventions by uncovering goal-gradient effects and imply that social cognitive theory and the Proteus effect can reliably incentivize PA.

Keywords: Avatars; Physical Activity; Social Cognitive Theory; Proteus effect; Goal-gradient effect.

1. Introduction

Virtual reality (VR) environments and computer games have gained much popularity in recent years. For this reason, there is a strong interest in how virtual experiences can improve health and quality of life outcomes (Joo & Kim, 2017). For example, virtual experiences may promote behavioral changes such as physical activity (PA) practice (Fox & Bailenson, 2009; Napolitano et al., 2013; Kim et al., 2014).

Specifically, exergames featuring realistic avatars (e.g., a digital self-representation of an individual user) may increase PA motivation, frequency, duration, and intensity (Thompson et al., 2018). In particular, using avatars which physically resemble their user can influence attitudes toward PA and increase its practice. For instance, participants randomly assigned to observe an avatar which gains or loses weight according to their concurrent PA performance on a treadmill show more effort in a subsequent PA task compared with those exposed to avatars that do not change weight based on PA performance or relative to those exposed to no avatars while engaging in PA (Fox & Bailenson, 2009). In order to influence PA practice, it is important for avatars to show the user's face in congruence with social cognitive theory (Fox & Bailenson, 2009). For example, participants exposed to avatars featuring their face while exercising report increased PA on the following day compared with participants exposed to loitering avatars or to avatars that do not show the participant's face (Fox & Bailenson, 2009).

Although there is promising evidence for how VREs can increase users' health behavior, it is necessary to further outline the theoretical mechanisms involved in designing effective studies and interventions to augment PA and health behaviors (Joo & Kim, 2017). In particular, social cognitive theory (Bandura, 2002), which assumes that individuals vicariously learn new behaviors by observing those actions in others that are similar to us, is a reliable framework in explaining the impact of VRE avatars on PA (Yu-Leung et al., 2019). In VR environments, individuals may observe and learn a given PA behavior from human-controlled avatars and or computer-controlled agents which act as models for users to learn new behaviors. VR avatars

may bear a strong physical resemblance to individual users (Yu-Leung et al., 2019). According to social cognitive theory, individuals are more likely to learn a behavior if they identify with the model (Bandura, 2002).

In addition to social cognitive theory predictions, the use of avatars with stereotyped physical characteristics may also influence PA practice (Clark et al., 2019). For example, women who are randomly assigned to thin avatars and then play a tennis video game show increased PA compared with those assigned to obese avatars (Peña & Kim, 2014). These results also replicate with a sample of men, who show increased PA when randomly assigned to thin instead of obese avatars (Peña et al., 2016). Similarly, overweight children randomly assigned to normal body size avatars show increased performance in a video game requiring PA, along with increased exercise motivation and more positive PA attitudes relative to those assigned to obese avatars (Li et al., 2014).

These results are linked to the Proteus effect, which predicts that individuals adapt their behavior to their avatar's identity and what they believe is expected of their virtual persona (Yee & Bailenson, 2007). According to Yee and Bailenson (2007), the Proteus effect is linked to self-perception theory (Bem, 1972), in which an avatar’s appearance triggers a temporary change of self-concept. According to Peña et al. (2009), the Proteus effect is grounded on automatic priming mechanisms, which predict that activating a concept or stereotype triggers associated thoughts and behaviors while inhibiting contrary concepts (Bargh et al., 1996).

Despite the growing interest on the influence of avatars on health behaviors, further research is necessary to draw firm conclusions about the impact of avatar physical appearance on PA practice (Clark et al., 2019). There is also a need for additional research linking social cognitive theory with the Proteus effect in order to specify conditions under which PA practice can be increased or decreased. To date, few studies have examined the intersection between social cognitive theory and the Proteus effect. Although Fox and Bailenson (2009) observe how participant avatar's face and onscreen avatar feedback influence PA, their study does not

explore the Proteus effect hypothesis that assigning users to avatars implying different activity levels through their stereotypical appearance (e.g., virtual character dressed in sports or formal clothes) may influence PA. This hypothesis has theoretical and practical implications, and thus it deserves examination as potential Proteus effects triggered by stereotypical physical characteristics of avatars on PA have not yet been charted. Consider that participants assigned to avatars dressed in casual clothing display greater intensity of movement when they played a drum relative to those assigned to avatars in formal clothing (Kilteni et al., 2013).

Based on the above, this study was designed to examine how avatar appearance can influence health-related behaviors by manipulating avatar facial resemblance and clothing as displayed onscreen while participants engage in PA performance. It explores how assigning participants to avatars dressed in sports or formal clothes influences PA while participants run in place as their movements are captured by a Kinect camera and displayed with an onscreen avatar which mimics participants' movements. The avatar may also display the participant's face or someone else's. The study is a 2 (avatar face display: participant, stranger) x 2 (avatar clothes: sports, formal) factorial experiment. Participants will run in place for twelve minutes (i.e., Cooper test) while their cardiac frequency and step counts are objectively measured with accelerometers. Based on social cognitive theory, exposure to an avatar displaying the user's face should increase cardiac frequency and step counts relative assignment to an avatar displaying a stranger's face. Based on the Proteus effect, exposure to an avatarsdressed in sports clothes should increase cardiac frequency and step counts relative assignment to an avatar dressed in formal clothes, as sports clothes are more linked to exercising than formal office clothes (Kilteni et al., 2013). Finally, interaction effects may include increased cardiac frequency and step counts in the sports clothes/participant face avatar condition relative to the remaining conditions.

Additionally, this study examines the temporal dimension of avatar-based interventions aiming at increasing PA practice. This is an important question to address as the duration of

avatar-based interventions has not been fully charted. Studies that measure PA using self-reports document long-lasting effects that endure up to 24-hours after exposure (Fox & Bailenson, 2009). However, studies that use behavioral PA variables, such as participant walking speed after embodying elderly avatars report that the effect only operates during the first half of a walking task, which implies fast effect decay rates (Reinhard et al., 2019). In order to clarify the duration of the effects of avatar-based interventions, this study focuses on the goal-gradient hypothesis and its interplay with social cognitive theory and the Proteus effect. The goal-gradient hypothesis predicts that individuals show more effort and accelerate their behavior the closer they get to achieving a goal (Hull, 1932). This hypothesis has been investigated extensively with animals (Brown, 1948; Anderson, 1933). Specifically, goal-gradient effects were initially observed in movement speed among rodents (Heilizer, 1977). Goal-gradient effects are also observed among humans. For instance, participants in a café reward program purchase coffee more frequently the closer they are to earning a free coffee (Kivetz et al., 2006). In addition, illusion of progress toward a goal increases purchase acceleration (Kivetz et al., 2006). Electronic machine gamblers also place the largest bets when they subjectively feel close to an inevitable payoff or prize (Li et al., 2016). Moreover, fundraisers, fund drives, and book drives that rely on goal-gradient frames (e.g., “We are halfway there…”) are more successful than drives that reply on paltry contributions frames (e.g., “Any penny helps…”) (Jensen et al., 2013). In regards to PA, success-oriented individuals show higher heart rate and energy consumption during a 1500 meter running task as the end goal approached in time (Halvari, 1991). This hypothesis has not been tested in studies on the influence of VR environments on PA practice and, thus, the present study attempts to contribute to the literature by documenting whether goal-gradient effects manifest themselves when using technology to encourage PA performance. Based on the assumptions of social cognitive theory, the Proteus effect, and the goal gradient hypothesis, this study proposes three hypotheses.

We hypothesize that participants randomly assigned to an avatar donning their own face will display (a) increased cardiac frequency and (b) more steps at latter PA stages than those assigned to avatars donning someone else's face; participants randomly assigned to an avatar wearing sports clothes will display (a) increased cardiac frequency and (b) more steps at latter PA stages than those assigned to avatars donning someone else's face; and participants randomly assigned to an avatar donning their own face also wearing sports clothes will display (a) increased cardiac frequency and (b) more steps at latter PA stages than those assigned to avatars donning someone else's face and wearing formal clothes.

2. Method

2.1. Participants

Participants (*N* = 305) were students at a large U.S. West Coast university and received extra credit for their participation. Age ranged from 18 to 37 (*M* = 20.02 years; *SD* = 2.22 years). Participants had a healthy body mass index (BMI) that ranged from 15.76 to 39.49 (*M* = 23.21, *SD* = 4.18). 54.2% of the participants were Asian, 20.4% were Latino, 20.1% were Caucasian, 1.3% were African-American, and 2.4% identified as other race. The eligibility criteria were to be an adult enrolled in classes, not having any physical condition that could prevent them from exercising, and not be pregnant. This study was approved by the university's institutional review board.

2.2. Measures and Materials

2.2.1. Cardiac frequency and step counts. Two ActiGraph accelerometers and a heart rate monitor (GT3X and GT9X) measured participants' cardiac frequency and step counts while playing the game. The accelerometers were located at two upper-body locations (dominant ankle and hip). The heart rate monitor was placed close to the chest and it contacted the participants' skin. They provided information on PA intensity in three dimensions using activity

counts that reflect the epochs in total). Higher cardiac frequency and step counts imply more intense PA during a given time period.

2.2.2. Similarity identification. This factor measured the degree to which participants identified with their avatar based on perceived physical resemblance (Van Looy et al., 2012). It consisted of five items on a 1 ("Totally disagree") to 5 ("Totally agree") Likert-type scale. The scale was reliable α = .929. Sample items included "My avatar is similar to me," and "I identify with my character."

2.2.3. Motion-tracking system. All participants ran in place in a lab room and their movements were captured with a Kinect camera and then projected on to a 150x150 cm screen. The virtual context was a 3D graphical environment representing a running trail at a park with the participant's avatar displayed at the center of the screen. Participants saw their avatar, the running trail, and their time and the distance metrics.

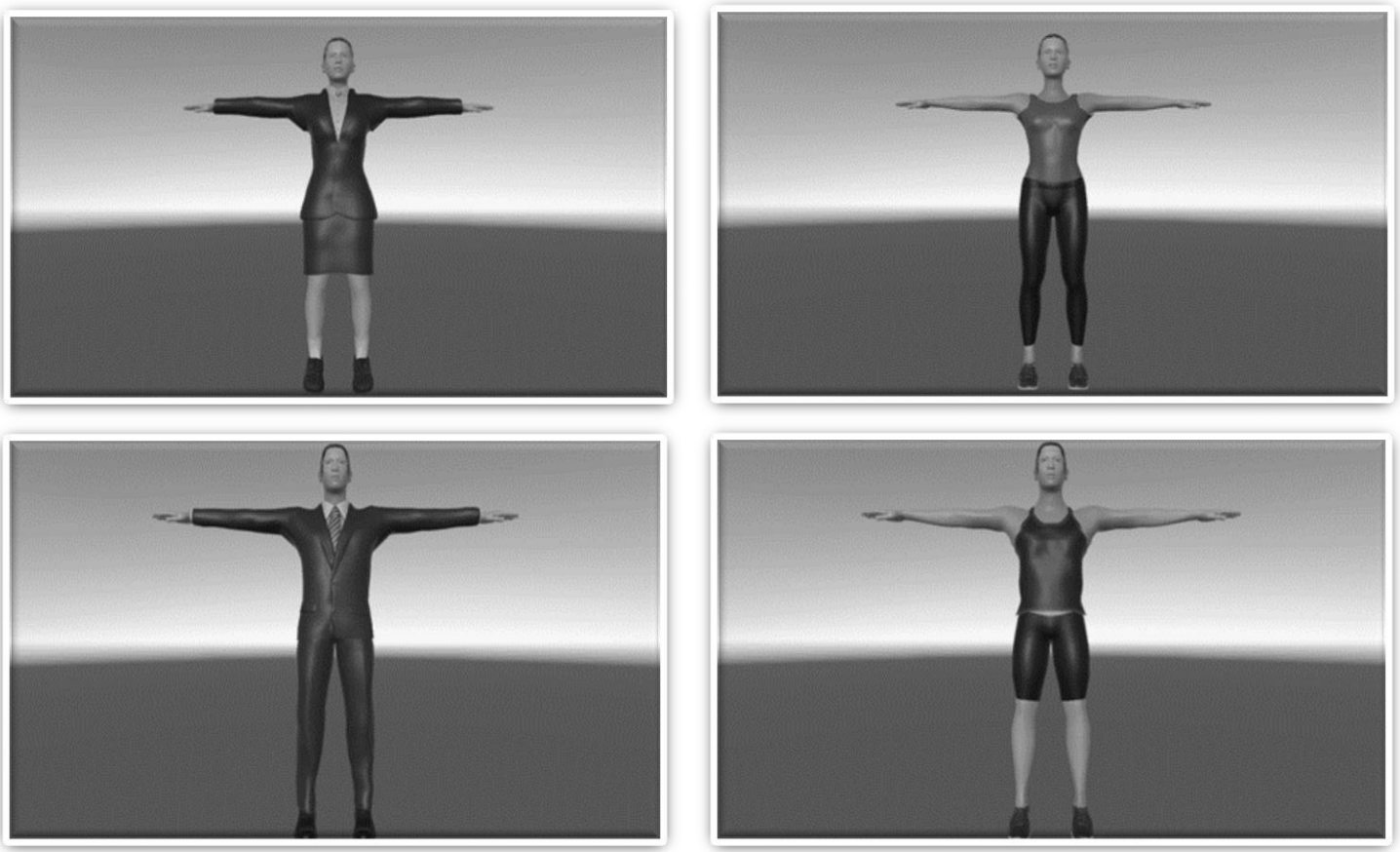
2.3. Procedure

The materials were pilot tested with a separate sample to establish whether avatar clothing activated mental concepts connected with sports or formal clothes. 283 adult participants (*N* = 283; age *M* = 34.27; *SD* = 11.58) were recruited through Mturk. Pilot-test participants were exposed to eight photographs of two avatars dressed either in sport or formal clothes. They were exposed to four perspectives: front, back, left, and right. Participants were asked to list three thoughts that came to their minds for each of the two avatars (3 thoughts per avatar, six thoughts in total per participant). Following this, they rated the two avatars in sports or formal clothes in regards to their perceived link with the PA practice. The avatar dressed in sports clothes was described with more concepts connected to motion $t(282) = 2.428$, $p = .016$, positive emotion $t(282) = 2.844$, $p = .005$, biological processes $t(282) = 8.625$, $p = .001$, health processes $t(282) = 8.119$, $p = .001$, body-related terms $t(282) = 3.197$, $p = .002$, and leisure $t(282) = 12.296$, $p = .001$ relative to the avatar dressed in formal clothes. Pilot test data implied that

avatars dressed in sports and formal clothes were capable of priming stereotypical concepts upon exposure.

The study itself was a 2 (avatar face: participant, stranger) x 2(avatar clothes: sports, formal) (see figure 1) factorial experiment. Upon arrival to the lab, participants were randomly assigned to one of the four avatar conditions using a table with randomized numbers: participant face in sports clothes (n = 76), stranger face in sports clothes (n = 79), participant face in formal clothes (n = 79), and stranger face and formal clothes (n = 75). Participants were furnished with an ankle and a hip Actigraph accelerometer and a heart rate monitor. Accelerometers placed in the ankle increased accuracy for measuring PA in walking and running tasks (Li et al., 2010). The hip accelerometer was necessary to measure cardiac frequency through the monitor. Participants then looked at their assigned avatar displayed on a large computer monitor were asked to think-out loud three concepts that came to their mind. Participants then got acquainted with a motion-tracking system, which displayed a running trail with their avatar displayed onscreen while a Kinect camera captured their arm, waist, and leg movements. The avatar mimicked the participants' arm, waist, and leg movements. Next, they performed the Cooper test, a PA task consisting of running as far as possible for 12 minutes. Participants ran on top of a high-density foam floor mat. The accelerometers measured participants' actual PA and cardiac frequency. After running, height and weight were measured.

Figure 1. Avatar Clothes Used in the Virtual Scenario.



2.4. Data analyses

Similarity identification scores were compared across the experimental conditions by a 2 x 2 x 2 ANOVA to establish whether participants identified with their randomly assigned avatar, which is a key mechanism in social cognitive theory. Participant's cardiac frequency was divided into three four-minute phases (beginning, middle, final) based on the 12 one-minute epoch measurements recorded by the heart rate monitor. An average for participants' cardiac frequency was created for each of the three phases. Similarly, step counts measured with the ankle accelerometer were averaged into three four-minute phases (beginning, middle, final) based on the 12 one-minute interval measurements. Outliers for cardiac frequency and step counts were identified using Tukey's hinges. Low and high outliers were excluded from the analysis for each dependent variable; only data falling between the first and third quartiles of cardiac frequency and step counts were considered to avoid biases based on participants exercising too little or too much. To establish whether a goal-gradient effect manifested itself in the PA data, cardiac frequency and step count at the beginning, middle, and final phases were compared against each other using paired samples t-tests. The results were analyzed with a two separate 2 x 2 ANCOVAs and BMI was used as a covariate in order to partial out the effect of each participant's body mass.

3. Results

3.1. Similarity Identification

A 2 x 2 x 2 ANOVA revealed that participants had increased similarity identification scores when the onscreen avatar had the participant's face relative to a stranger's face, $F(1, 297) = 8.629$, $p = .004$, $\eta^2 p = .028$. Participants also showed increased similarity identification scores when assigned to avatars dressed in sports in comparison to formal clothes, $F(1, 297) = 11.110$, $p = .001$, $\eta^2 p = .036$. Male participants had increased similarity identification scores relative to female participants, $F(1, 297) = 5.805$, $p = .017$, $\eta^2 p = .019$. There were no two or three-way

statistical interactions. In sum, random assignment to perform a PA task while seeing one's own face in an avatar increased similarity identification. Assignment to avatars dressed in sports instead formal clothes also increased similarity identification. Men had increased similarity identification scores relative to women. The results are summarized in Tables 1 and 2.

Table 1. Descriptive Statistics for Avatar Face Manipulation and Similarity Identification Scores for Male, Female, and Total Participants.

	Similarity identification					
Avatar face	Men		Women		Total	
	M (SD)	*N*	*M (SD)*	*N*	*M (SD)*	*N*
Participants face	2.80 (1.02)	78	2.66 (1.06)	77	2.73 (1.04)	155
Stranger face	2.63 (1.03)	73	2.19 (0.94)	77	2.41 (1.01)	150

Table 2. Descriptive Statistics for Avatar Clothes Manipulation and Similarity Identification Scores for Male, Female, and Total Participants.

	Similarity identification					
Avatar clothes	Men		Women		Total	
	M (SD)	*N*	*M (SD)*	*N*	*M (SD)*	*N*
Formal clothes	2.59 (1.02)	72	2.18 (.95)	79	2.38 (1.01)	151
Sport clothes	2.83 (1.03)	79	2.69 (1.03)	75	2.76 (1.03)	154

3.2. Goal-Gradient Effect

In regards to cardiac frequency, participants' displayed faster heart rates in final phase (*M* = 150.310, *SD* = 29.599) relative to the beginning (*M* = 126.839, *SD* = 37.679) and middle phases (*M* = 143.725, *SD* = 30.830), *t*(282) = 10.438, *p* = .001, *d* = .621 and *t*(290) = 9.010, *p* = .001, *d* = .528, respectively. Participants' also exhibited faster heart rates in the middle relative to the beginning phase, *t*(282) = 8.198, *p* = .001, *d* = .487. In regards to step counts, participants displayed increased step counts in the final phase (*M* = 76.713, *SD* = 11.147) compared with the beginning (*M* = 74.606, *SD* = 10.020) and middle phases (*M* = 75.591, *SD* = 10.139), *t*(211) = 2.617, *p* = .01, *d* = .180 and *t*(211) = 2.780, *p* = .006, *d* = .191, respectively. There were no step count differences between the beginning and middle phase, *t*(211) = 1.386, *p* = .167, *d* = .095. Overall, the goal-gradient effect was reliably present in participant's cardiac frequency and step counts.

3.3. Differences between conditions in PA variables.

Relative to men, women's cardiac frequency was significantly higher in all three phases, $F_{beginning\ phase}(1, 274) = 17.681$, $p = .001$, $\eta^2p = .061$, $F_{middle\ phase}(1, 274) = 6.251$, $p = .013$, $\eta^2p = .022$, and $F_{final\ phase}(1, 274) = 5.083$, $p = .004$, $\eta^2p = .018$.

Although there were no differences for the beginning phase $F_{beginning\ phase}(1, 274) = .294$, $p = .588$, $\eta^2p = .001$, participants who were randomly assigned to avatars donning the participant's own face showed increased cardiac frequency by the middle and final phases of the PA task relative to those who were assigned to an avatar with a stranger's face, $F_{middle\ phase}(1, 274) = 5.371$, $p = .021$, $\eta^2p = .019$ and $F_{final\ phase}(1, 274) = 8.225$, $p = .004$, $\eta^2p = .029$. No other main or interaction effects were found, all *F*s = ns. H1a was confirmed but H2a was disconfirmed. Descriptive statistics are summarized in Tables 3, 4, and 5.

In regards to step counts, there were no main effects or gender differences. H1b and H2b were not supported. Although there were no differences for the beginning and middle phases, there was a significant interaction effect for step counts in the final phase, $F_{beginning\ phase}(1, 203) = 2.657$, $p = .105$, $\eta^2p = .013$, $F_{middle\ phase}(1, 203) = 2.760$, $p = .098$, $\eta^2p = .013$, and $F_{final\ phase}(1, 203) = 3.930$, $p = .049$, $\eta^2p = .019$. Among participants assigned to the avatar in sports clothes, those who saw their own face performed more steps at the final phase relative to participants who saw an avatar with a stranger's face, $t(102) = 1.664$, $p = .045$, $d = .321$ (one-tailed). No significant interaction effect between participant gender, avatar face, and avatar clothes were found. H3a-b were disconfirmed. Descriptive statistics appear in Tables 6, 7 and 8.

Table 3. Descriptive Statistics for Avatar Face Manipulation and Cardiac Frequency for Male, Female, and Total Participants.

	Cardiac frequency																	
	Beginning						Middle						Final					
Avatar face	Men		Women		Total		Men		Women		Total		Men		Women		Total	
	M (SD)	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*
Participants	119.20	73	137.26	69	127.98	142	144.34	73	151.31	69	147.73	142	152.96	73	157.51	69	155.17	142
face	(46.66)		(24.08)		(38.38)		(29.76)		(20.46)		(25.81)		(28.36)		(21.35)		(25.22)	
Stranger	116.99	73	135.03	68	125.69	141	135.01	73	144.72	68	139.69	141	140.36	73	150.84	68	145.41	141
face	(44.90)		(23.05)		(37.05)		(43.70)		(20.69)		(34.79)		(39.47)		(22.74)		(32.80)	

Table 4. Descriptive Statistics for Avatar Clothes Manipulation and Cardiac Frequency for Male, Female, and Total Participants.

	Cardiac frequency																	
	Beginning						Middle						Final					
Avatar clothes	Men		Women		Total		Men		Women		Total		Men		Women		Total	
	M (SD)	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*
Formal clothes	115.69 (48.62)	73	138.05 (22.82)	66	126.31 (40.05)	139	135.43 (42.62)	73	146.80 (20.69)	66	140.83 (34.38)	139	143.54 (37.84)	73	153.73 (22.75)	66	148.37 (31.89)	139
Sport clothes	120.51 (42.66)	73	134.39 (24.17)	71	127.35 (35.37)	144	143.93 (31.40)	73	149.18 (20.91)	71	146.52 (26.79)	144	149.78 (31.48)	73	154.64 (21.88)	71	152.17 (27.19)	144

Table 5. Descriptive Statistics for Avatar Appearance Manipulation and Cardiac Frequency for Total Participants.

	Cardiac frequency											
	Stranger face		Participant face		Stranger face		Participant face		Stranger face		Participant face	
Avatar appearance	Beginning				Middle				Final			
	M (SD)	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M(SD)*	*N*	*M (SD)*	*N*
Formal clothes	124.94 (43.23)	67	127.58 (37.12)	72	135.91 (37.96)	67	145.40 (30.24)	72	141.89 (34.65)	67	154.40 (28.00)	72
Sport clothes	126.37 (30.71)	74	128.39 (39.91)	70	143.11 (31.53)	74	150.12 (20.23)	70	148.59 (30.93)	74	155.96 (22.17)	70

Table 6. Descriptive Statistics for Avatar Face Manipulation and Steps Counts for Male, Female, and Total Participants.

	Step counts																	
	Beginning						Middle						Final					
Avatar face	Men		Women		Total		Men		Women		Total		Men		Women		Total	
	M (SD)	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*
Participants	76.21	57	73.97	52	75.14	109	75.59	57	76.19	52	75.87	109	76.97	57	76.82	52	76.89	109
face	(10.99)		(10.49)		(10.77)		(11.34)		(7.57)		(9.69)		(11.48)		(10.70)		(11.06)	
Stranger	73.53	48	74.48	55	74.04	113	74.06	48	76.36	55	75.29	113	75.46	48	77.44	55	76.52	113
face	(9.24)		(9.18)		(9.17)		(13.64)		(7.01)		(10.63)		(14.51)		(7.44)		(11,28)	

Table 7. Descriptive Statistics for Avatar Clothes Manipulation and Steps Counts for Male, Female, and Total Participants.

	Step counts																	
	Beginning						Middle						Final					
Avatar clothes	Men		Women		Total		Men		Women		Total		Men		Women		Total	
	M (SD)	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*
Formal clothes	75.55 (11.98)	52	74.01 (10.65)	56	74.75 (11.28)	108	75.01 (11.33)	52	76.27 (8.19)	56	75.66 (9.80)	108	76.52 (12.53)	52	76.70 (11.22)	56	76.61 (11.81)	108
Sport clothes	74.43 (8.34)	53	74.47 (8.88)	51	74.45 (8.57)	104	74.77 (13.49)	53	76.28 (6.14)	51	75.51 (10.52)	104	76.05 (13.39)	53	77.61 (6.17)	51	76.81 (10.47)	104

Table 8. Descriptive Statistics for Avatar Appearance and Steps Counts for Total Participants.

	Step counts											
	Stranger face		Participant face		Stranger face		Participant face		Stranger face		Participant face	
Avatar appearance	Beginning				Middle				Final			
	M (SD)	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M (SD)*	*N*	*M(SD)*	*N*	*M (SD)*	*N*
Formal clothes	75.30 (7.86)	54	74.19 (13.95)	54	76.46 (7.80)	54	74.86 (11.48)	54	77.88 (8.81)	54	75.35 (14.17)	54
Sport clothes	72.64 (10.35)	49	76.07 (6.26)	55	74.00 (13.03)	49	76.86 (7.51)	55	75.02 (13.44)	49	78.41 (6.56)	55

4. Discussion

This study harnessed the predictions of social cognitive theory and the Proteus effect in order to test how exposure to avatars donning participant's or stranger's faces while dressed in sport or formal clothes would influence PA practice in a controlled experimental setting. A key contribution of this research was to document the temporal dimension of avatar-based interventions used to influence PA practice by focusing on the goal-gradient hypothesis. Participants showed increased cardiac frequency and step counts at the final phase of a PA task. These results confirmed that the goal-gradient effect manifested itself in the study. To our knowledge, this is the first study to report goal-gradient effects in when using avatars and exergames to incentivize PA.

Moreover, randomly assigning participants to avatars donning their own face increased cardiac frequency by the middle and final phases of the PA task relative to those assigned to an avatar with a stranger's face. The results illustrate how social cognitive theory principles can be implemented to incentivize PA. When performing the Cooper test while their movements were displayed onscreen with an avatar that mimicked their behaviors, exposing participants to avatars donning their face may have increased vicarious learning and identification. This finding also provided initial evidence for the interplay between social cognitive theory and goal-gradient effects. Although available studies imply a fast decay rate in which behavioral effects were observed at initial stages, our results suggested that avatar manipulations can influence PA at later stages. Based on social cognitive theory, it is possible that participants paid more attention to a virtual avatar model when it displayed their own face as they progressed through the PA task. Social cognitive theory also predicts that individuals relate and learn more from similar instead of dissimilar virtual avatar models. This interpretation was further reinforced by participants expressing increased similarity identification when assigned to avatars donning their own face relative to a stranger's face. In addition, participants may have been more inclined to check on their own facial expression for signs of sweat, fatigue, or effort relative to

participants assigned to an avatar wearing a stranger's face. Future studies should continue exploring goal-gradient effects in particular and the temporal dimension of avatar-based interventions more generally to clarify PA effect decay rates.

Although PA effects of avatar-based interventions had been documented earlier, this study made distinct contributions. Instead of asking participants to exercise after exposure to avatars with different faces and counting voluntary exercise repetitions or measuring walking speed following avatar use (Fox & Bailenson, 2009; Reinhard et al., 2019), this study employed accelerometers and heart rate monitors, which allowed for more accurate PA quantification. In addition, instead of asking participants to exercise after avatar exposure (Fox & Bailenson, 2009; Reinhard et al., 2019), we measured PA in real time as participants ran in place under different avatar exposure conditions.

Additionally, among participants randomly assigned to an avatar in sports clothes, those who saw their own face showed increased step counts at the final PA phase compared with participants who saw an avatar with a stranger's face. These findings supported social cognitive theory and the Proteus effect predictions, and also illustrated goal-gradient effects as avatar face and clothing manipulations influenced PA more reliably at later instead of initial phases. It is possible that participants found the sporty avatar with their own face more relatable relative to the remaining conditions. Note that there were no main effects of avatar clothing on PA and the observed interaction effect was statistically small. This implies that participants likely paid less attention to avatar clothes relative to their own face. It is possible that the primary object of perception was the avatar's face whereas clothing might have been noticed at first but then became less focal. Future research should employ eye-tracking techniques in order to determine participant's attention foci while exercising in front of an onscreen avatar, along with how visual attention to virtual models relates to PA outcomes.

Although the findings were statistically significant, they were small in statistical size. Future studies should also attempt to replicate these results with different populations as the

majority of the participants had normal weight. In addition, avatar face manipulations showed more consistent effects relative to avatar clothing manipulations. As noted above, it is possible that participants paid more attention to their face when projected onto an avatar instead of attending to their avatar's clothing. Considering this, feedback effects in which participants used their virtual model's face to check on their own performance need to be further investigated. Overall, the results implied that we have the capacity to use virtual avatar models to incentivize PA by relying on known psychological mechanisms such as social cognitive theory, the Proteus effect, and the goal-gradient hypothesis.

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CHAPTER 5. Study 4

Manipulating self-avatar body dimensions in virtual worlds to complement an Internet-delivered intervention to increase physical activity in overweight women

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Abstract

Virtual reality has been found to be a useful tool for positively influencing relevant psychological variables in order to increase physical activity (PA), especially in the overweight population. This study investigates the use of avatars and their physical variations to extend the effectiveness of existing interventions to promote PA. The main objective is to analyze the influence of the avatars' body dimensions on the efficacy of an Internet intervention to increase PA levels and improve other relevant variables (motivation toward PA, enjoyment, anxiety, self-efficacy, and PA goals). A total of 42 overweight women received a brief online intervention, and they were randomly assigned to one of three conditions: the "Ideal avatar" (IAC: participants are represented by avatars with ideal body dimensions); the "Real avatar" (RAC: participants are represented by avatars with participants' current body dimensions); and the "Non avatar" (NAC: participants are not represented by avatars). Results showed that the online intervention was effective in increasing PA practice and self-efficacy expectations. However, manipulating the body dimensions of avatars did not improve this intervention, although ideal avatars helped to reduce the anxiety experienced during PA in this population.

Keywords: physical activity; overweight; virtual reality; virtual environments; avatars; intervention.

1. Introduction

Physical inactivity and sedentariness are considered serious health problems with great economic, social, and individual impact (Ding et al., 2016). National and worldwide associations and institutions have proposed a series of recommendations for the minimum amount of physical activity (PA) required for health (WHO, 2010). However, the majority of overweight people do not meet these minimums (Pleis & Lucas, 2009).

Empirical evidence has shown relationships between low PA levels and several psychological variables, such as low self-efficacy expectations, low motivation, low enjoyment, negative body representations, or anxiety during PA, among others (Ball et al., 2000; James, 2000; Katula & McAuley, 2001; Hausenblas & Fallon, 2002; Ginis et al., 2003; Kruger et al., 2008; Williams et al., 2008; Bauman et al., 2012; Teixeira et al., 2012; Riva et al., 2013; Dakanalis et al., 2016). In addition, different interventions have been designed to change this tendency, including Internet-delivered interventions (Davies et al., 2012). These interventions have been found to increase PA motivation in normal and overweight populations (Davies et al., 2012), although their long-term effectiveness has not been established (Davies et al., 2012; Joseph et al., 2014).

Other technologies, such as virtual reality (VR), have also been proposed as helpful tools for learning healthy behaviors, such as PA habits (Yee & Bailenson, 2007; Fox & Bailenson, 2009), and there is evidence that virtual experiences can promote PA practice (e.g., Fox & Bailenson, 2009; Napolitano et al., 2013; Kim et al., 2014).

The use of VR has several advantages, such as the ability to manipulate body representations (Petkova, & Ehrsson, 2008; Song et al., 2014; Serino et al., 2016) and increase self-efficacy expectations, motivation, or adherence. For instance, some studies have shown that using avatars that physically resemble the user can increase expectations of self-efficacy toward PA and motivate adherence to the practice (Fox & Bailenson, 2009; Ruiz et al., 2012) in normal-weight individuals. These results can be explained by Bandura's social cognitive theory (Bandura, 1986), which assumes that individuals vicariously learn new behaviors by observing

these behaviors in others (Bandura, 1986). In VR scenarios, avatars can have a strong physical resemblance to individual users (Yu-Leung et al., 2019) and individuals are more likely to learn a behavior if they identify with the model (Bandura, 1986).

Regarding the overweight and body dissatisfied population, research shows that avatar resemblance increases awareness of a negative body image and anxiety during PA practice. Authors such as Song et al. (2014) found that when participants with body image dissatisfaction embodied avatars representing their ideal body, they showed greater enjoyment and decreased anxiety levels during PA practice. Therefore, using avatars with different body dimensions could help individuals to overcome body representation difficulties during PA practice (Petkova, & Ehrsson, 2008; Serino et al., 2016) and, consequently, encourage them to exercise (Song et al., 2014).

Several studies have pointed out that manipulation of the body dimensions of virtual avatars can influence PA practice (Ruiz et al., 2012; Peña & Kim, 2014; Li et al., 2014; Peña et al., 2016). Specifically, participants embodying normal-weight avatars showed more PA on a virtual task, compared to overweight avatars (Li et al., 2014; Peña & Kim, 2014; Peña et al., 2016). These results can be explained by the "Proteus effect" (Yee & Bailenson, 2007), which assumes that individuals change their behavior in accordance with the characteristics and appearance of their avatars, in order to conform to the expectations and stereotypes of these avatars. Some research has found support for this effect in different VR experiences (Groom et al., 2009; Yee et al., 2009).

To date, studies on the influence of avatars on PA practice have consisted of sessions where the avatar's physical characteristics were manipulated and the impact on the execution of a PA task was analyzed at that moment (Ruiz et al, 2012; Li et al., 2014; Peña & Kim, 2014; Peña et al., 2016) or in the subsequent practice of PA within a short period of time (Fox & Bailenson, 2009). However, no studies have tested whether the use of avatars and their physical variations can enhance the effectiveness of existing interventions to increase the level of PA.

The aim of the present study is to analyze the influence of avatars' body dimensions on the efficacy of an Internet-delivered intervention specifically designed to increase PA levels in overweight and obese sedentary women. In order to test this objective, participants receive a brief online intervention (Miragall et al., 2018), enriched with a virtual task using avatars. Three conditions are compared, according to the virtual task participants have to perform: a) the "Ideal avatar condition" (IAC: participants are represented by avatars with body dimensions they rated as "ideal"); b) the "Real avatar condition" (RAC: participants are represented by avatars with their own current body dimensions); and c) the "Non avatar condition" (NAC: participants are not represented by avatars while performing PA). The influence of these experimental conditions on several relevant psychological variables (motivation, enjoyment, anxiety, self-efficacy, and PA goals) will be analyzed.

We hypothesize that all participants will improve their PA levels after the intervention. In addition, we hypothesize that participants represented by avatars (IAC and RAC conditions) will show a significantly higher PA level and achievement of PA goals than NAC participants. We also hypothesize that IAC and RAC participants will increase their scores on motivation, enjoyment, and self-efficacy, and this increase will be higher than in NAC participants. In addition, we expect that IAC participants will choose more ambitious PA goals and show lower anxiety while performing PA, compared to RAC participants. Finally, we hypothesize that similarity to the avatar and self-efficacy expectations will mediate between the conditions and the increase in PA levels after the intervention.

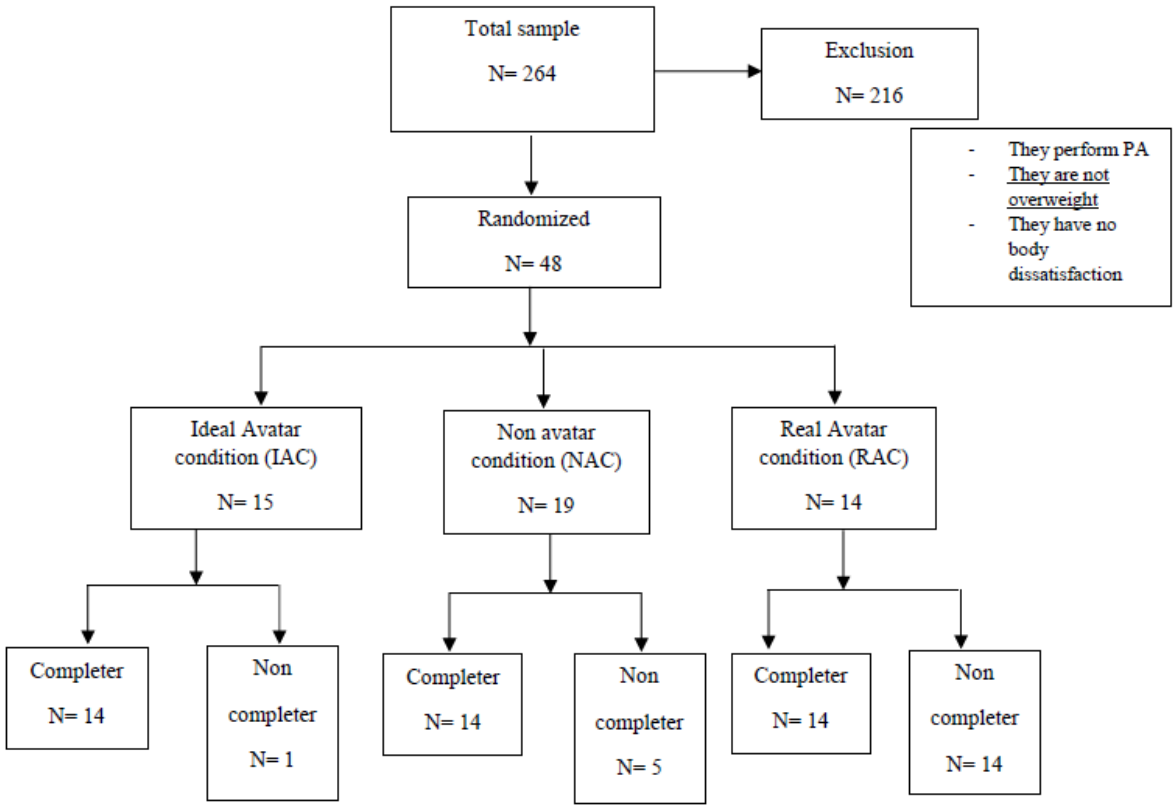
2. Method

2.1. Participants

The final sample was composed of 42 overweight and obese women (BMI, *M* = 28.7; SD = 3.1) who were sedentary and had high body dissatisfaction (see participants' recruitment flow in Figure 1). Their ages ranged from 19 to 61 years (*M* = 31.9; *SD* = 11.7). Participants were

recruited in nutrition clinics and gyms. Because participants had to show low activity levels, the gyms only contacted women who had dropped out. Flyers and in-person presentations were used to publicize the study. The eligibility criteria were: being a woman from 18–64 years old; being overweight (BMI > 25); having high body dissatisfaction (Body Schema Questionnaire—BSQ— > 80); being physically inactive; and not having any physical condition that could keep them from practicing PA. Of the total 216 participants excluded from the study, 70% of the them were excluded because they were not overweight, and 30% of the remaining participants were excluded for reasons related to PA practice (e.g., they were physically active) or body dissatisfaction (e.g., they showed no body dissatisfaction). Participants were informed about the study, and they signed informed consent documents. This study was approved by the Ethical Committee of the University of Valencia (Spain).

Figure 1. Participants' Recruitment Flow.



2.2. Measures and Materials

2.2.1. Anthropometric and sociodemographic data. An ad-hoc questionnaire was created to collect information about sociodemographic data, height, and weight.

2.2.2. Body Shape Questionnaire (BSQ; Cooper et al., 1987). It consists of 34 items, rated on a scale from 1 to 6 (1 = "never" to 6 = "always"), that evaluate the dissatisfaction produced by one's body, the fear of gaining weight, self-devaluation due to physical appearance, the desire to lose weight, and avoidance of situations where one's physical appearance could attract the attention of others. The measure is the composite sum of the items, and higher scores reflect greater body dissatisfaction in the past four weeks. There are four categories of concern: "no concern" (<81), "mild concern" (81-110), "moderate concern" (111-140), and "extreme concern" (>140) (Cooper et al., 1987). The cut-off point for inclusion in this study was 81. The Spanish version used in this study showed adequate internal consistency (Raich et al., 1996).

2.2.3. International physical activity questionnaire (IPAQ; Craig et al., 2003): Through 31 items, this questionnaire collects data on PA performed in the past 7 days. It identifies the frequency and duration of moderate and vigorous leisure, transportation and occupational PA, walking PA, and inactivity during the past week. The IPAQ has reported test-retest reliability correlations of 0.81 and validity correlations with accelerometers of 0.33 (Gauthier et al., 2009).

2.2.4. Weekly PA goal registration*:* This ad hoc record collects data on the weekly achievement of the specific PA goal in all the conditions, as well as the video display for the IAC and RAC conditions. The two possible goals were walking or running three times a week. All participants were free to choose one of these two goals.

2.2.5. Behavioral Regulation in Exercise Questionnaire (BREQ-2; Markland & Tobin, 2004). This questionnaire is based on the theory of self-determination, which provides insight into the reasons people adopt and maintain healthy behaviors (Deci & Ryan, 1985, 2000). It consists of 19 items, rated on a scale from 0 to 5 (0 = "Not at all true for me" to 5 = "absolutely true for me"), that measure stages on the continuum of self-determination in PA behavior. This

questionnaire assesses external regulation, introjected regulation, identified regulation, and intrinsic regulation, and it adds demotivation. The BREQ-2 has shown acceptable internal consistency (Murcia et al., 2007).

2.2.6. Self-efficacy to regulate exercise (ESE; Bandura, 2006). It consists of 18 items, rated on a scale from 0 to 100 (0 = "not at all sure" to 100 = "Very sure"), that evaluate how sure the person is about regularly performing an exercise routine (three or more times per week). The measure is the composite mean of the items, and higher scores reflect greater PA self-efficacy. This scale has been shown to be a useful measure of exercise self-efficacy expectations in several populations (Everett et al., 2009; Darawad et al., 2017; Sabo et al., 2019).

2.2.7. Enjoyment (PACES; Motl et al., 2001): This questionnaire consists of 16 items, rated on a scale from 1 to 5 (1= "Strongly disagree" to 5= "Strongly agree"), that evaluate the degree of enjoyment of PA. The measure is the composite mean of the items, and higher scores reflect more enjoyment of PA. PACES has been a useful instrument to measure enjoyment in different fields of PA (Moreno et al., 2008).

2.2.8. The physical activity and sport anxiety scale (PASAS; Norton et al., 2004). This is a 16-item self-report that assesses social fear and avoidance of sports and PA on a scale from 1 ("not at all characteristic of me") to 5 ("extremely characteristic of me"). This measure has demonstrated good internal consistency, test-retest reliability, and convergent and divergent validity (Norton et al., 2004).

2.2.9. Avatar identification modified questionnaire (Van Looy et al., 2012). It consists of 17 items, rated on a scale from 1 ("Strongly disagree") to 5 ("Strongly agree"), that assess the degree of embodied presence, perceived similarity, and the participant's desire to identify with the avatar. This self-report has been shown to be a reliable measure of identification in online games (Van Looy et al., 2012).

2.2.10. VR program: The VR scenario consisted of a 3D graphical environment representing a park where an avatar runs. Avatars' characteristics varied depending on the

experimental condition (IAC and RAC). In the IAC and RAC conditions, the participant's face was tracked by the Kinect. All participants ran in place in a room, and their movements were captured by a Kinect and projected on a 150x150 cm screen. During the PA task, participants could see the time and distance they had run on the screen.

2.2.11. Online Intervention: This brief one-session intervention is based on the trans-theoretical model components of behavior change (Prochaska & DiClemente, 1982), and it has shown its effectiveness in previous studies (Miragall et al., 2018). It consists of two parts: the first one, "Motivation for Change", provides information on PA, recommendations, consequences of physical inactivity, and possible barriers; the second part, "Move it", focuses on helping participants to find their own motivation and set their specific PA goals for the future. For a more detailed description, see (Miragall et al., 2018). The entire intervention lasted about 45 minutes, and the specific time spent on the intervention screen was recorded for each participant.

2.3. Procedure

After the participants contacted us, they were informed about the contents of the study by telephone, and they signed the informed consent by email. Participants who met the criteria were randomly assigned to one of the three conditions (IAC: 14; RAC: 14; NAC; 14), using the Random Allocation Software 2.0 (This software has been developed by M. Saghaei, MD., Department of Anesthesia, Isfahan University of Medical Sciences, Isfahan, Iran). First, they were sent an email with the link to fill out the questionnaires online. Then, they received a link with the online intervention they had to follow for a week to increase PA. The specific time spent on this online intervention was registered for each participant. After seven days, participants were individually invited to the laboratory, where the virtual PA task was applied for about 10 min. The virtual task varied in the three conditions (see figure 2).

(a) IAC participants were asked to create an avatar with their ideal body dimensions and their own face. They were shown a default avatar and were able to change its body dimensions. Then, they performed a running task for 4 min in a VR scenario where they were represented by this avatar. The VR task performance was video-recorded, and participants received this video on their mobile phones and were asked to watch it every day of the week.

(b) RAC participants received the same instructions, but they were asked to change the avatar (with their face) to fit their real body dimensions.

(c) NAC participants were asked to perform the PA task in the VR scenario for 4 min, but participants were not represented by an avatar. They ran in front of a fixed image corresponding to the VRE. They did not receive any video-recordings.

Finally, all participants were asked to choose a weekly PA goal (walking or running three times a week). A week later, they received an email with the link to answer the questionnaires online. Finally, all participants came back to the lab to report on the achievement of the PA goals and receive their reward for completing the study (an invitation to a gymnasium where they could participate in sports activities and study their physical condition). All participants were met by blinded study staff.

Figure 2. Avatar Creation.

2.4. Data analyses

Statistical analyses were conducted using the SPSS for Windows (version 24) (This software has been developed by Norman H. Nie, Dale H. Bent, and C. Hadlai Hull., University of Stanford, United states). First, to assess the influence of the avatars' body dimensions on PA, repeated-measures ANOVA were performed on each variable (motivation, enjoyment, anxiety, self-efficacy, and PA levels), with condition (3: IAC, RAC, and NAC) as between factor and time (2: pre versus post intervention) as within factor. In addition, univariate ANOVAs were carried out to analyze the differences between conditions in the time spent on the intervention, video display during the week, and the achievement of PA goals. When a significant interaction was found, post-hoc analyses using Bonferroni adjustment were conducted to determine which group comparisons were significant.

Second, to check differences between conditions in the PA goal chosen, a chi-square test was performed, using Monte Carlo with 10,000 samples as a 99% level of confidence. When the absolute value of the Adjusted Standardized Residual was greater than 1.96, there were significant differences between conditions. Subsequently, effect sizes (Cohen´s *d)* and confidence intervals were calculated for within-group changes, given that effect sizes are the

best indicator of the magnitude of the observed changes, which is essential information that cannot be obtained by focusing exclusively on p-values (Durlak, 2009).

Finally, using Model 6 from PROCESS 3.3, we performed two serial multiple mediation analyses to test whether the effects of condition on the change in PA were mediated by self-efficacy and perceived similarity to the avatar. The procedure described by Hayes (2013) was performed using the PROCESS macro for SPSS. Significance tests ($p < .05$) or a confidence interval (not including zero) for the interaction answered this question.

3. Results

3.1. Adherence to tasks

3.1.1. Time spent on the online intervention. Descriptive statistics can be found in Table 1. For the time spent on the intervention, the results showed a wide range from 1 minute to 372 minutes (M =46.71; SD = 68.49). Results did not show differences between conditions F (2, 40) = 0.25, p = .779, η^2p = 0.01.

Table 1. ANOVA Results for Baseline Measures and Intervention Adherence.

Measure	Condition	*N*	M (SD) Baseline	*p*
PA levels	NAC	14	2499.81 (2231.45)	0.571
	RAC	14	1902.33 (971.67)	
	IAC	14	2552.98 (1927.08)	
	Total	42	2318.37 (1773.36)	
Intrinsic Regulation	NAC	14	10.57 (3.41)	0.413
	RAC	14	9.64 (1.82)	
	IAC	14	10.93 (2.34)	
	Total	42	10.38 (2.60)	
Identified Regulation	NAC	14	10.93 (3.22)	0.091
	RAC	14	11.71 (3.27)	
	IAC	14	13.29 (1.64)	
	Total	42	11.98 (2.92)	
Introjected Regulation	NAC	14	9.00 (1.62)	0.423
	RAC	14	8.71 (1.07)	
	IAC	14	9.43 (1.55)	
	Total	42	9.05 (1.43)	
External Regulation	NAC	14	10.57 (3.41)	0.634
	RAC	14	10.71 (1.86)	
	IAC	14	11.36 (0.93)	
	Total	42	10.88 (2.28)	

Demotivation	NAC	14	10.07 (4.32)	0.264
	RAC	14	8.36 (3.65)	
	IAC	14	7.93 (2.67)	
	Total	42	8.79 (3.65)	
Enjoyment	NAC	14	60.64 (11.47)	0.323
	RAC	14	63.79 (10.89)	
	IAC	14	66.86 (9.91)	
	Total	42	63.76 (10.82)	
Anxiety	NAC	14	47.93 (13.08)	0.253
	RAC	14	40.93 (16.34)	
	IAC	14	38.71 (15.65)	
	Total	42	42.52 (15.24)	
Self-efficacy	NAC	14	469.28 (185.45)	0.111
	RAC	14	646.43 (317.29)	
	IAC	14	752.14 (483.23)	
	Total	42	622.62 (361.68)	
Body Mass Index	NAC	14	29.39 (3.57)	0.627
	RAC	14	28.42 (2.69)	
	IAC	14	28.35 (3.22)	
	Total	42	28.72 (3.13)	
Motivational Intervention	NAC	14	38.69 (38.37)	0.779
	RAC	14	57.43 (96.23)	
	IAC	14	44.76 (65.00)	
	Total	42	46.71 (68.49)	
Avatar Video	NAC	14	-----	0.552
	RAC	14	5.79 (1.93)	
	IAC	14	6.14 (1.09)	
	Total	28	5.96 (1.55)	
Body Dissatisfaction	NAC	14	117.07 (23.45)	0.817
	RAC	14	116.57 (30.61)	
	IAC	14	110.86 (31.15)	
	Total	42	114.83 (28.06)	

Note. PA levels (for a week) = IPAQ; Intrinsic Regulation = BREQ-2 (20); Identified Regulation = BREQ-2 (20); Introjected Regulation = BREQ-2 (15); External Regulation = BREQ-2 (20); Demotivation = BREQ-2 (20); Enjoyment = PACES (80); Anxiety = PASAS (80); Self-efficacy = ESE (1800); Body Mass Index = BMI; Motivational Intervention = minutes dedicated to the online intervention; Avatar Video = days a week of viewing; Levels of Body Dissatisfaction = BSQ (204). The score in brackets is the maximum score in the questionnaire.

3.1.2. Watching the avatar video during the week. Descriptive statistics can be found in Table 1. Most of the participants watched the video daily (M =5.96; SD = 1.55). There were no differences across conditions F (1, 27) = 0.36, p = .552, η^2p = 0.01.

3.2. Efficacy results: Differences between conditions

Descriptive statistics and within-group effect sizes (measured by Cohen´s d) can be found in Table 2.

Table 2. Descriptive Statistics and Within-Group Effect Sizes for Outcomes.

Measure	Condition	N	M (SD) Pre	M (SD) Post	*p*	Within-group effect size, d [95% CI] Pre-post intervention
Intrinsic Regulation	NAC	14	10.57 (3.41)	10.29 (2.61)		0.08 [−0.58, 0.73]
	RAC	14	9.64 (1.82)	11.07 (1.64)	0.076	**−0.74 [−1.47, −0.01]**
	IAC	14	10.93 (2.34)	9.93 (2.09)		0.40 [−0.28, 1.08]
Identified Regulation	NAC	14	10.93 (3.22)	11.21 (2.08)		−0.08 [−0.56, 0.39]
	RAC	14	11.71 (3.27)	13.00 (3.03)	0.347	−0.37 [−0.87, 0.13]
	IAC	14	13.29 (1.64)	13.21 (2.78)		0.05 [−0.43, 0.52]
Introjected Regulation	NAC	14	9.00 (1.62)	9.43 (0.85)		−0.25 [−0.85, 0.35]
	RAC	14	8.71 (1.07)	9.00 (1.30)	0.736	−0.26 [−0.86, 0.35]
	IAC	14	9.43 (1.55)	9.43 (1.34)		−0.00 [−0.59, 0.59]
External Regulation	NAC	14	10.57 (3.41)	10.07 (2.09)		0.14 [−0.46, 0.73]
	RAC	14	10.71 (1.86)	10.50 (1.95)	0.811	0.11 [−0.49, 0.69]
	IAC	14	11.36 (0.93)	10.57 (1.34)		**0.80 [0.11, 1.48]**
Demotivation	NAC	14	10.07 (4.32)	7.86 (2.32)		0.48 [−0.08, 1.04]
	RAC	14	8.36 (3.65)	8.29 (2.37)	0.139	0.02 [−0.50, 0.54]
	IAC	14	7.93 (2,67)	7.57 (2.28)		0.13 [−0.39, 0.65]
Enjoyment	NAC	14	60.64 (11.47)	62.71 (12.02)		−0.17 [−0.73, 0.39]
	RAC	14	63.79 (10.89)	63.43 (9.34)	0.776	0.03 [−0.52, 0.58]
	IAC	14	66.86 (9.91)	69.14 (7.37)		−0.22 [−0.77, 0.34]
Anxiety	NAC	14	47.93 (13.08)	37.71 (12.09)		**0.74 [0.29, 1.18]**
	RAC	14	40.93 (16.34)	40.43 (16.95)	0.016	0.03 [−0.29, 0.35]
	IAC	14	38.71 (15.65)	32.57 (16.49)		**0.37 [0.01, 0.73]**
Self-efficacy	NAC	14	469.28 (185.45)	760.71 (355.77)		**−1.48 [−2.32, −0.64]**
	RAC	14	646.42 (317.28)	775.71 (416.75)	0.38	−0.38 [−0.96, 0.19]
	IAC	14	752.14 (483.22)	852.85 (389.72)		−0.20 [−0.75, 0.36]
PA levels	NAC	14	2499.80 (2231.45)	3884.92 (2671.75)		**−0.58 [−1.14, −0.03]**
	RAC	14	1902.32(971.66)	3065.23 (1924.58)	0.949	**−1.13 [−1.81, −0.44]**
	IAC	14	2552.97 (1927.08)	3733.87 (2428.44)		**−0.58 [−1.13, −0.02]**

Note. Intrinsic Regulation = BREQ-2; Identified Regulation = BREQ-2; Introjected Regulation = BREQ-2; External Regulation = BREQ-2; Demotivation = BREQ-2; Enjoyment = PACES; Anxiety = PASAS; Self-efficacy = ESE; PA levels (for a week) = IPAQ. **Bold letter** = effect of sizes of greater magnitude.

3.2.1. PA levels (IPAQ; Craig et al., 2003): Regarding the ANOVA results, there was a main effect of time on PA levels F (1, 39) = 15.82, p = .000, η^2p = 0.29. All participants showed higher PA levels after the intervention. However, the interaction between time and condition was not significant F (1, 39) = 0.05, p = .949, η^2p = 0.00.

3.2.2. PA goals (walking or running three times a week). No significant effects were found on the achievement of the PA goal F (2, 41) = 0.36, p = .702, η^2p = 0.02. Regarding the specific PA goal chosen, despite the trends found, chi-square analyses showed no differences between conditions χ2 (2, N = 42) = 3.20, p = .202, Cramer´s V = .28. The percentages of the specific PA goals chosen in each condition are shown in Table 3. The specific PA goal of walking was chosen by 73.8% of the participants.

Table 3. Chi-Square Test Results.

		NAC	RAC	IAC	Total
Walking	Count	12	11	8	31
	Expected count	10.3	10.3	10.3	30.9
	%	38.7	35.5	25.8	100
	ASR	1.2	0.5	−1.7	--
Running	Count	2	3	6	11
	Expected count	3.7	3.7	3.7	11.1
	%	18.2	27.3	54.5	100
	ASR	−1.2	-0.5	1.7	--

Note. Count = number of participants who choose the PA goal; Expected count = number of participants expected to choose the PA goal; % = percentage of participants who choose the PA goal; ASR = Adjusted standardized residuals.

3.2.3. Motivation toward PA *(*BREQ-2; Markland & Tobin, 2004). No effect of time was found on any subscale (intrinsic regulation F (1, 39) = 0.12, p = .913, η^2p = 0.00, identified regulation F (1, 39) = 1.65, p = .207, η^2p = 0.04, introjected regulation F (1, 39) = 1.10, p = .300, η^2p = 0.03, external regulation F (1, 39) = 1.93, p = .173, η^2p = 0.05, and demotivation F (1, 39) = 3.57, p = .066, η^2p = 0.08). No interactions between time and condition were significant for any subscale (intrinsic regulation F (2, 39) = 2.76, p = .076, η^2p = 0.12, identified regulation F (2, 39) = 1.09, p = .347, η^2p = 0.05, introjected regulation F (2, 39) = 0.31, p = .736, η^2p = 0.02, external regulation F (2, 39) = 0.21, p = .811, η^2p = 0.01, and demotivation F (2, 39) = 2.07, p = .139, η^2p = 0.09).

3.2.4. Enjoyment (PACES; Motl et al., 2001). No time effect was found on enjoyment F (1, 39) = 0.63, p = .432, η^2p = 0.02, and the interaction effect between time and condition was not significant either F (2, 39) = 0.25, p = .776, η^2p = 0.01.

3.2.5. Anxiety (PASAS; Norton et al., 2004). There was a main effect of time on total anxiety during PA practice F (1, 39) = 18.18, p = .000, η^2p = 0.32. All participants showed lower anxiety levels during PA after the intervention. In addition, the interaction between time and condition was also significant F (2, 39) = 4.57, p = .016, η^2p = 0.19. Post- hoc comparisons using Bonferroni correction revealed that IAC and NAC participants showed lower anxiety levels during PA after the intervention (p = .010 and p =.000), compared to RAC participants.

3.2.6. Self-efficacy (ESE; Bandura, 2006). There was a main effect of time on self-efficacy toward PA F (1, 39) = 8.49, p = .006, η^2p = 0.18. However, despite the trends found, the interaction between time and condition was not significant F (2, 39) = 0.99, p = .380, η^2p = 0.05.

3.3. Similarity to the avatar and self-efficacy expectations as mediators: Do similarity to the avatar and self-efficacy influence PA practice?

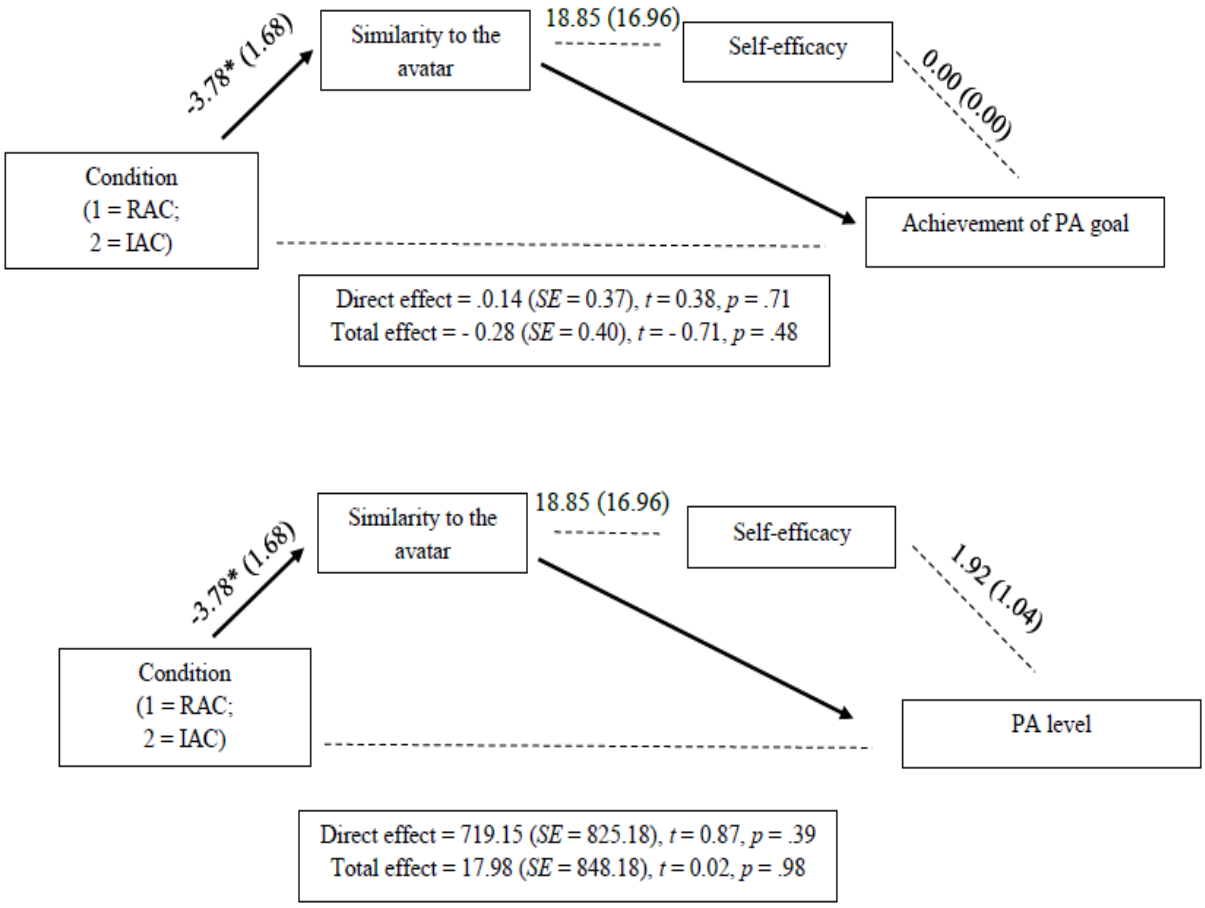
Two serial multiple mediation analyses were carried out to test whether the effects of condition on the change in PA (PA levels and achievement of PA goals) were mediated by similarity to the avatar and self-efficacy expectations.

Regarding the effects on the achievement of the PA goal (Figure 3), the indirect effect of "Condition → change in similarity to the avatar → achievement of PA goal was significant, implying that similarity to the avatar mediated the relationship between the condition and achievement of the PA goal, b = -0.40, SE = 0.25, 95% CI [-1.15, -0.07]. This result means that participants who perceived the avatar as similar to themselves showed greater achievement of the PA goal. In contrast, the other two indirect effects tested in this serial multiple mediation model were not significant: a) Indirect effect of "Condition → change in self-efficacy→ achievement of PA goal", b = 0.03, SE = 0.18, 95% CI [-0.14, 0.62]; b) Indirect effect of "Condition

→ change in similarity to the avatar → change in self-efficacy → achievement of PA goal", *b* = -0.05, *SE* = 0.09), 95% CI [-0.48, 0.01].

Regarding the effects on PA levels (Figure 1), none of the indirect effects were significant: a) Indirect effect of "Condition → change in similarity to the avatar → changes in PA levels", *b* = -646.29, *SE* = 588.49, 95% CI [-2142.42, 103.55]: b) Indirect effect of "Condition → change in self-efficacy → change in PA levels", *b* = 82.18, *SE* = 304.67, 95% CI [-692.18, 563.01]: c) Indirect effect of "Condition → change in similarity to the avatar → change in self-efficacy → change in PA levels, *b* = -137.06, *SE* = 163.95, 95% CI [-512.75, 131.89].

Figure 3. Serial Multiple Mediation Analysis.



Note. * $p < 0.05$

4. Discussion

This study was conducted to analyze the influence of avatars' body dimensions on the efficacy of an online intervention to increase PA levels, as well as the influence on other relevant variables (motivation toward PA, enjoyment, anxiety, self-efficacy, and PA goals), in a sample of overweight women and body dissatisfied women. A second aim was to explore whether the effects of the condition on the change in PA (PA levels and achievement of PA goals) were mediated by the similarity to the avatar and self-efficacy expectations.

The first hypothesis assumed that the intervention would be effective in increasing PA levels in all participants, regardless of the condition. This hypothesis was confirmed because significant increases were found in PA levels and self-efficacy expectations after the intervention in all participants. Previous studies with this intervention showed its effectiveness in a sample of university students (Miragall et al., 2018). Specifically, previous results revealed that it had been effective in increasing awareness of the positive consequences of PA practice, influencing the strategies used to modify the PA habit, increasing enjoyment during PA practice, and, consequently, increasing the number of weekly steps. The results of this study confirm the efficacy of this brief online intervention in overweight and obese populations. These data are quite promising because it is a very short, self-applied intervention and can be quite cost effective in increasing PA in different populations. It would be interesting to include a follow-up measure to show the medium- and long-term effects of this intervention.

The second hypothesis proposed that participants represented by avatars (IAC and RAC) would show higher levels of PA, achievement of goals, motivation, self-efficacy, and enjoyment, compared to NAC participants. In addition, we expected that IAC participants would choose more ambitious goals and show lower anxiety while performing PA because using avatars with different body dimensions has been shown to help individuals to overcome body representation difficulties during PA practice (Petkova, & Ehrsson, 2008; Serino et al., 2016). This hypothesis was only confirmed for anxiety scores. The IAC participants showed lower levels of anxiety

compared to RAC participants. However, it is important to highlight that the NAC participants scored the lowest on anxiety. NAC participants were not represented by any avatar or exposed to their body during the virtual PA task, and they performed the PA task in front of an image of a park, which could act as a distracting stimulus from their own body. Our results suggest that the use of avatars in virtual scenarios can elicit anxiety in overweight and body dissatisfied individuals by increasing self-body image awareness (Song et al., 2014), and this anxiety induction could be higher with avatars representing their real body dimensions rather than ideal body dimensions. According to the literature, dissatisfaction with body image acts as a barrier to PA practice (Ball et al., 2000; Kruger et al., 2008) especially in contexts where body image is more prominent, such as group PA or mirror environments (James, 2000; Katula & McAuley, 2001; Hausenblas et al., 2002; Ginis et al., 2003). Our results seem to support this line of research. The use of avatars in the context of overweight and dissatisfied women may enhance the anxiety experienced towards PA since the avatar highlights the individual's body image, especially when the avatar represents the real self.

Regarding the lack of significant differences in PA levels and the goal chosen across conditions, our manipulation failed to bring about a major change in PA levels or the choice of a more ambitious goal in IAC participants. First, a high percentage of participants (61.9%) reported that they had successfully achieved their objective. Because they reported this achievement at a face-to-face meeting, social desirability may have had an effect on this report (Latkin et al., 2017). Perhaps it would have been preferable to record the achievement online rather than in a face-to-face visit. Regarding the choice of the PA goal, 73.8% of the participants chose to walk, that is, the less ambitious goal. These results are not surprising, as the evidence shows that brisk walking is the preferred PA type for overweight women (Schutz et al., 2014). Therefore, it would have been more appropriate not to compare two such different objectives (running versus walking) but to measure the intensity of the PA performed, for example, by providing participants with an accelerometer during the PA practice that measures the intensity of

walking. It seems that manipulating the avatar while performing the intervention has no effect on promoting a more ambitious goal in the participants.

Despite the lack of differences, it is important to highlight the changes observed in the RAC condition. According to standardized effect sizes (Cohen's *d*), this group obtained a large effect size (>0.80) for their change in PA levels, and they increased their weekly practice the most. Similarly, the results also showed: a medium effect size (<0.50) for intrinsic motivation in the RAC participants, who increased their intrinsic motivation scores the most; a large effect size (>0.80) for external motivation in the IAC participants, who increased their external motivation scores the most; and a large effect size (>0.80) for self-efficacy expectations in participants in the NAC condition, who increased their self-efficacy expectations scores the most. Given these results, although through this study no significant differences between the groups can be concluded, it would be interesting to increase the statistical power of the study. It is possible that increasing the sample size, greater differences might be found.

The third hypothesis proposed that similarity to the avatar and self-efficacy expectations would mediate between the condition and PA practice. This hypothesis was partially confirmed in the case of achievement of the PA goal. Participants who had judged their avatar to be more similar to themselves were more likely to reach the PA goal. These results are in line with the literature, showing that virtual self-models can be effective instigators of PA change (Fox & Bailenson, 2009). In general, research shows that when individuals personalize their avatars they self-report higher behavioral intentions, as measured by the percentage of time they intended to spend on maintaining good health (Clark et al., 2019; Peña et al., 2020). However, intentions and actual behavior associated with such intention did not always correlate and results did not always go in the same direction (Kim & Sundar, 2012), which could explain the absence of differences in weekly PA levels. The lack of significance of self-efficacy expectations as a mediator between the condition and the achievement of the PA goal could be due to the characteristics of the sample. Other studies have concluded that, although an increase in self-

efficacy in normal weight participants has an impact on PA, in obese or overweight people, this effect is not significant (Olander et al., 2013).

Some limitations of the current study should be mentioned. The first is that, due to technical limitations, NAC participants did not use a dynamic VR scenario, but rather a fixed image. It would be desirable for all participants to use a VR scenario, with or without an avatar. Second, assessments were only carried out before and after the intervention, and it would be preferable to have more assessments moments (e.g., different times throughout the PA task), as well as follow-ups.

As future lines, it would be desirable to include follow-ups to analyze the long-term effects of the intervention as well as to include women without body dissatisfaction.

In conclusion, the online intervention used in this study was effective in increasing PA practice and self-efficacy expectations in overweight women. Manipulating the body dimensions of avatars did not improve this intervention. Using ideal avatars seems to reduce the anxiety experienced during PA in this population. However, the use of avatars similar to the person him/herself could have a greater impact on PA and variables related to its long-term practice.

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CHAPTER 6. General Discussion

1. Summary of the main findings

As presented throughout this dissertation, the physical activity (PA) practice has undoubted benefits on the physical and mental health of individuals. However, a large part of the population does not meet the recommended minimums. There are different barriers to the PA practice among which are interpersonal (e.g., school, family and friends) and the existence of practical and material resources such as time and economic resources. In addition, there are other barriers related to the self (e.g., lack of confidence in one's abilities, feelings of discomfort during PA, lack of motivation, preference for other skills, lack of knowledge about the benefits of PA, and self-awareness about the body and physical appearance). Virtual reality (VR) has proven to be a useful tool in combating these obstacles. That VR is a useful tool to enhance PA seems to be a consistent and conclusive statement. However, in relation to its influence on psychological and physiological variables there are still questions to be resolved. Furthermore, during the last few years the role of virtual representations of the self (e.g., avatars) in VR environments has been highlighted. It seems that the physical appearance of the avatar is a key factor to take into account. However, studies are scarce and their results inconclusive.

Hence, the main objectives of this dissertation were firstly to analyze the motivation for the practice of PA in adolescents. To do so, the BREQ-2 questionnaire was validated in Spanish adolescents and the role of motivation in PA practice was analyzed in this population. Secondly, our objectives focused on analyzing the influence of VR environments and virtual representations of users on PA practice and specific interventions designed to promote this behavior.

More specifically, the four general objectives were: (1) To validate the psychometric properties of an instrument aimed at assessing different levels of motivation towards PA in the Spanish adolescent population, as well as to analyze the differences in motivation according to sex and age; and the role of age and sex in the relationship between motivation and enjoyment of PA; (2) To analyze the influence of using VR to influence the PA practice and physical and

psychological variables related to its practice; (3) To investigate the influence of the avatar's physical appearance on the practice of PA and physical and psychological variables related to the practice in several populations; and (4) To investigate the effectiveness of using avatars to complement online interventions to improve PA practice.

To do so, four experiments were carried out. In the following subsections, a general discussion will be presented, putting together all the results derived from these studies.

1.1. Psychometric properties of *Behavioural Regulation in Exercise Questionnaire- 2* (BREQ-2) in the Spanish adolescent population

Study 1 was aimed at to validate the psychometric properties of an instrument aimed at assessing different levels of motivation towards PA in the Spanish adolescent population, as well as to analyze the differences in motivation according to sex and age; and the role of age and sex in the relationship between motivation and enjoyment of PA.

Results of study 1 allowed us to conclude a 5-factor structure in the BREQ-2 questionnaire for types of behaviour regulation in PA in the adolescent population. However, a four-factor structure with a single intrinsic regulation identified with appropriate adjustment also emerged. This study has also shown that the different types of PA regulation fluctuate according to age and sex. Furthermore, this study shows that the most self-determined types of regulation are positively associated with psychological constructs related to PA practice. Finally, this study highlights the importance of encouraging specific types of behaviour regulation to increase enjoyment as a function of age in order to develop PA interventions.

As discussed in the chapter 2, the results support the existence of a 5-factor structure for the types of behaviour regulation in PA in the adolescent population. As discussed above, the theory of self-determination (SDT) is a macro theory of human motivation and personality that provides insight into the reasons people adopt and maintain health behaviours (Deci & Ryan, 1985; 2000). SDT suggests that the regulation of PA is supported by different levels of

motivation, from intrinsic regulation to extrinsic regulation and amotivation. In this context, the BREQ-2 questionnaire assesses four types of motivation towards PA (external, introjected, identified and intrinsic regulation) and amotivation. In this study, the existence of these 5 factors was confirmed in the questionnaire. However, a four-factor structure with appropriate adjustment also emerged. Specifically, introjected regulation, external regulation and amotivation were maintained, as already occurred in other validations performed (Verloigne et al., 2011; Crăciun & Rus, 2012), but the items of intrinsic and identified regulation were loaded into the same factor with high internal consistency. Chen et al. (2018) also found this factor to combine both types of regulation into a unique autonomous form of regulation. Considering the cultural distance between Chinese and Spanish adolescents, the findings indicate that it may not be worthwhile to distinguish between the intrinsic and the identified in adolescents.

Regarding the nomological validity of BREQ-2, correlations between types of PA regulations close to each other in the continuum were positively correlated, while they were negatively correlated with those on the opposite side of the continuum. In addition, social anxiety in PA and physical social anxiety were negatively correlated with more self-determined forms of regulation while they were positively correlated with more external forms of regulation and amotivation. On the other hand, enjoyment of PA was positively correlated with more self-determined forms of regulation, and negatively with external regulation and amotivation. These results are consistent with other studies that found positive affective responses to PA to be positively associated with intrinsic regulation and self-determined forms of extrinsic regulation in PA (Thogersen-Ntoumani & Ntoumanis, 2006; Edmunds et al., 2008; Zhang, 2009; Sanchez-Oliva et al, 2014; Sicilia et al, 2014). Therefore, interventions aimed at increasing PA should encourage and strengthen self-determined types of regulation of PA in order to increase enjoyment and decrease social anxiety related to PA. This is especially relevant because some of these constructs (e.g., enjoyment, social anxiety related to the physical appearance) are the

main reason for not achieving the minimum levels of PA (Babic et al., 2014; Lewis et al., 2014), especially in girls (Robbins et al., 2003; Portela-Pino et al., 2020).

In terms of the differences in the types of PA regulation strategies according to age and sex, on the one hand, young adolescents showed greater intrinsic, identified and external motivation than did average adolescents. In contrast, middle adolescents showed more amotivation than young adolescents. On the other hand, boys showed more intrinsic motivation than girls. Some studies (e.g., Butt et al., 2011) have already found that males were more motivated by intrinsic factors, while females were motivated by extrinsic factors. It seems that young adolescents have a wide range of ways to regulate their PE. This makes sense within SDT, which is not conceptualized as a developmental continuum or stage model, as everyone may have different levels of motivations or multiple goals acting simultaneously (Deci & Ryan, 1985; 2000). These results highlight the need to adapt interventions aimed at promoting physical PA to the age and sex of the individual.

Finally, age moderated the relationship between behaviour regulation and the enjoyment of PA. Results indicated that improving some types of regulation in PA in young or middle adolescents has different effects on the enjoyment of PA. In young adolescents, greater intrinsic and identified regulation was associated with greater enjoyment of PA. However, in middle-aged adolescents, greater introjected regulation was associated with less enjoyment of PA. Future interventions aimed at increasing motivation towards PA should take into account the age of the adolescent to try to increase enjoyment. In younger adolescents, interventions could focus on improving intrinsic and identified regulation in PA, whereas in middle-aged adolescents, interventions should avoid improving introjected regulation.

In conclusion, this study allows us to conclude that the BREQ-2 questionnaire is a useful tool to measure motivation towards PA in the Spanish population. Furthermore, this study confirms once again that motivation towards PA is a variable to be taken into account in order

to understand PA behavior due, among other things, to its relationship with other variables that also predict this behavior.

1.2. Influence of using VR environments to influence the PA practice

The second objective of this dissertation was analyzed mainly through study 2, which included a VR environment and analyzed its effect on physical and psychological variables related to PA practice. As discussed in this dissertation, a bot is an autonomous agent that pursues its own objectives. In contrast, an avatar is a representation of a human being that is under the direct control of that human being (Whalen et al., 2003). In this study, participants used a bot because they did not really control speed even though they thought they did.

The results of study 2 allowed us to conclude that VR environments that allow manipulation of the experience of success or failure during PA can influence psychological variables (e.g. affect and arousal) as well as task execution (e.g. speed). In addition, individual-related variables such as predispositional motivation towards PA and expectations about one's ability are moderating variables to be considered when analysing the effect of VR on PA.

As discussed in Study 2, the VR environment used and the manipulation of success or failure influenced variables such as affect, arousal, and speed during the PA task. However, it did not influence other variables considered such as subjective fatigue and heart rate. The results showed that when users had successful experiences, they progressively showed higher scores in positive affect, arousal and speed. Such results were consistent with other studies concluding that VR scenarios that create positive user experiences can positively influence PA practice (Krause & Benavidez, 2014) and positive affect experienced during PA can improve PA performance (McCarthy, 2011). These results highlight one of the strengths of VR environments that has been discussed earlier in this dissertation. The VR environment can be controlled and manipulated and this offers many opportunities to improve PA practice (Alhadad & Abood, 2018).

Similarly, study 2 confirmed the moderating role of individual variables related to self-efficacy towards PA and motivation. Specifically, when individuals experienced success through VR, individuals with higher expectations of skill and competence showed higher levels of activation during the PA task. In addition, individuals who initially showed greater intrinsic motivation showed greater speed during the race. Conversely, when individuals experienced failure experiences the individuals who scored lower in amotivation showed greater arousal in the PA task. These results seem to indicate that depending on these individual characteristics, VR environments can influence in one way or another. These results are in line with a recent review by Neumann et al (2018). In this review, the authors argued that the VR environments improved performance (e.g., adherence, distance, speed, physical intensity exercised, persistence in the task and strategy) (Ijsselsteijn et al., 2004; Anderson-Hanley et al., 2011; Irwin et al., 2012; Snyder et al., 2012; Hoffmann et al., 2014; Chen et al., 2015; Murray et al., 2016), the physiological effects of PA practice (e.g., heart rate, oxygen consumption and blood lactate level, muscle fatigue and electroencephalogram amplitude and frequency) (Snyder et al., 2012; Nunes et al., 2014; Chen et al., 2015; Oliveira et al., 2015; Vogt et al., 2015), and the psychological effects (e.g., motivation, perceived effort, focus of attention and positive and negative emotional states) (e.g., Ijsselsteijn et al., 2004; Mestre et al., 2011; Anderson-Hanley et al., 2012; Nunes et al., 2014; Baños et al., 2016). However, these authors also argued that such results were not always found because there are moderating variables explaining these influences. These variables are mainly related to the VR system and to the user. Specifically, the user characteristics (e.g., physical characteristics, skill, experience, and psychological characteristics) have the potential to mediate or moderate the effects of VR on psychological performance and outcomes.

The results derived from study 2 show the effectiveness of a VR environment in manipulating the feedback received during a PA task and, consequently, its influence on physical and psychological PA responses.

1.3. The influence of the avatar's physical appearance on the PA practice

The third objective of this dissertation was analyzed through study 3, which is closely related to the previous study. This study analyses the effectiveness of VR environments to manipulate the physical appearance of the avatar during a PA task and, consequently, its influence on physical responses. This study took advantage of predictions from social cognitive theory and the Proteus effect to test how exposure to user-controlled avatars wearing the faces of participants or strangers while wearing sportswear (e.g., tracksuit and sneakers) or formal wear (e.g., jacket suit and shoes) would influence PA practice (steps counts and heart rate) in a controlled experimental setting.

The results of study 3 allowed us to conclude that the use of avatars with the participant's face served to increase the heart rate during the middle and final phase of the race, compared to the use of avatars with a strange face. In addition, among participants randomly assigned to an avatar in sportswear, those who saw their own face showed an increase in the number of steps in the final phase of PA compared to participants who saw an avatar with a stranger's face. These results revealed that the avatar's face and clothing manipulations influenced PA more reliably in the later stages than in the early stages. As discussed in Chapter 4, this could be explained by the goal gradient hypothesis, which predicts that individuals show more effort and accelerate their behavior the closer they come to achieving a goal (Hull, 1932). The results once again support the physical appearance of the avatar as a key factor to consider in the context of influencing healthy behaviors (Clark et al., 2019; Peña et al., 2020).

In addition, the results revealed that in terms of the physical characteristics of the avatar analyzed in this study, the avatar's clothing showed less relevance, compared to the avatar's face. These results are in line with the studies conducted by Fox & Bailenson, (2009) and Li & Lwin (2016). Both studies show that a key factor in learning healthy behaviors is the similarity between the model and the self. As discussed in chapter 4, it could be that despite having

manipulated several physical characteristics of the avatar (face and clothing), individuals pay more attention to the avatar's face.

In general, the results implied the possibility of using virtual avatar models to encourage PA by relying on psychological mechanisms known as social cognitive theory, the Proteus effect and the goal gradient hypothesis. Once again, the importance of customizing avatars used in interventions aimed at increasing PA practice is highlighted. So far, one of the most supportive customizations is the avatar face.

1.4. The effectiveness of using avatars to complement online interventions to improve PA practice

The fourth objective of the dissertation was analyzed in study 4. This study analyzed the influence of the body dimensions of avatars on the efficacy of an Internet-based intervention specifically designed to increase PA levels in overweight sedentary women. Therefore, this study aimed to go one step further by including avatars and their physical manipulations (body dimensions) in specific interventions.

The results of study 4 allowed us to conclude that online interventions are effective in increasing PA levels and self-efficacy expectations in overweight women. Regarding the influence of including avatars and manipulating their body dimensions, as discussed in Chapter 5, the results revealed that including avatars in interventions aimed at overweight women does not improve the intervention, which is the case with other types of populations (Behm-Morawitz et al., 2016; Horne et al., 2020). In this case, the results indicated that including avatars in interventions aimed at overweight women seems to increase the levels of anxiety experienced during PA. These results are in line with other studies such as those of Song et al. (2014) who claim that the use of avatars in virtual scenarios can elicit anxiety in overweight and body dissatisfied individuals by increasing self-body image awareness. Similarly, it should be noted that when individuals were represented by avatars with ideal body dimensions, they

showed lower levels of anxiety compared to avatars with real body dimensions. This result is also consistent with existing literature. The use of avatars with different body dimensions has been shown to help individuals overcome difficulties in body representation during PA practice (Petkova, & Ehrsson, 2008; Serino et al., 2016).

Despite the anxiety experienced, overall, participants who had judged their avatar to be more similar to themselves were more likely to achieve the weekly PA goal. These results are in line with the literature, showing that virtual self-models can be effective instigators of PA change (Fox & Bailenson, 2009). Furthermore, the effect sizes found seem to support this idea. The effect sizes showed that "real" avatars had been associated to variables such as intrinsic motivation towards PA, while “ideal” avatars have been associated to external motivation. As predicted in SDT (Deci & Ryan, 1985; 2000; 2007) the intrinsic motivation is related to the increase of PA practice in the long term, so the results found with the “real” avatars seem to be more promising.

In conclusion, the online intervention used in this study was effective in increasing PA practice and expectations of self-efficacy in overweight women, which is a very important contribution of this study. In addition, manipulation of the body dimensions of avatars did not improve this intervention. The use of ideal avatars appears to reduce the anxiety experienced during PA in this population. However, the use of person-like avatars may have a greater impact on PA and related variables in long-term practice.

In general, studies 2, 3 and 4 allow us to conclude that VR environments can be useful tools to promote the PA practice in different populations (children, adults and overweight population). As discussed above, barriers to PA can be understood as a set of factors that significantly predict PA practice. That is, developing interventions aimed at combating such barriers helps us to promote PA practice in the population. Barriers may be intrapersonal (e.g., lack of confidence in one's own abilities, feelings of discomfort during PA, lack of motivation, preference for other skills, lack of knowledge about the benefits of PA and self-awareness about

the body and physical appearance) and interpersonal (e.g., school, family and friends) as well as the existence of practical and material resources. In order to overcome such barriers and promote PA, different models and theories have been developed and have already proven their effectiveness. Among these models are the cognitive social theory (Bandura, 1986), the theory of self-determination (Decy & Ryan, 1985), the trans-theoretical model (Prochasca & DiClemente, 1983), the theory of reasoned action (Fishbein & Ajzen, 1975) and the social ecological model (Brofenbrenner, 1976). Such models have been presented in this dissertation because all of them have shown their effectiveness mainly in the short term. In addition, there are some barriers that by using these theories and models, can be understood, but cannot be easily overcome. Through the use of VR and virtual representations (bots and avatars), it is possible to take into account such models and influence all the barriers presented. This dissertation has mainly shown how VR environments and the use of virtual representations are useful in influencing mainly intrapersonal barriers related to having a better experience during PA practice (e.g., affect, arousal and anxiety during PA). Similarly, the development of VR environments where users have been able to perform PA individually and even accompanied by other virtual representations, is evidence that VR allows us to influence interpersonal barriers as well and can also provide resources needed for PA practice.

2. Strengths

For my point of view, this dissertation has several strenghts that add robustness to main findings:

- This dissertation includes a very novel topic in experimental, clinical and health psychology about which there are few studies and many questions to be resolved.
- This dissertation analyses the impact of VR on PA in different populations (children, adults, general population and clinical population such as overweight women).

- This dissertation includes new VR environments that have been designed specifically for these studies, which can be used in the future. In fact, at the University of Davis, California, they are currently conducting other studies using our VR environment.
- This dissertation includes variables related to the avatar's appearance that have never been included in previous studies, such as the avatar's clothing and its influence on PA practice.
- This dissertation analyses whether the use of avatars and their physical variations can enhance the effectiveness of existing interventions to increase the level of PA. To date, studies on the influence of avatars on PA practice have consisted of sessions where the avatar's physical characteristics were manipulated and the impact on the execution of a PA task was analyzed at that moment or in the subsequent practice of PA within a short period of time.
- This dissertation examines the intersection between two theories that attempt to explain the influence of avatars on PA practice, social cognitive theory and the proteus effect. To date, few studies have done so.
- This dissertation includes accelerometers and heart rate monitors to measure more precisely the influence of avatars on the PA practice.
- This dissertation includes contributions from international universities. Study 3 was conducted at the University of Davis, California, with Professor Jorge Peña.

3. Limitations

Nevertheless, this dissertation is not exempt from limitations. The individual discussion of each study has explained the specific limitations, but this subsection will last all the common limitations of the four studies:

- The literature shows there might be a dose-dependent relationship between the level of immersion induced by the VR system and the magnitude of the resulting outcomes

(Ijsselsteijn et al., 2004; Vogt et al., 2015; Neumann et al., 2018). In this dissertation, a semi-immersive system (Alhadad & Abood, 2018) has been used and the immersion of the individual in the VR environment has not been measured.

- Even that the minimum sample size needed was calculated for all studies, it was not always met. It is possible that the inclusion of larger samples may help provide more generalizable results and increase statistical power.
- This dissertation does not include follow-up measures in any of the studies, which does not permit to analyze the long-term effects produced by the VR environments. In addition, only study 3 performs more than one measure over the course of the PA task.
- This dissertation does not include a control group in all its studies, which limits the conclusion of the results found on the effects of VR on the PA practice.

4. Future directions

In addition, to overcome the above mentioned limitations in future studies, this dissertation leaves open questions and new challenges that will be presented in the next paragraphs.

First, it is important to use VR environments that are as immersive as possible and to include this measure in the protocol of the study. For example, it is possible to include more multimodal elements in the VR environment (Vogt et al. 2015). When a study is proposed to analyse the influence of VR on the PA practice, we must talk about interactive VR and always measure presence and immersion. Both variables should be considered as moderating variables (Neumann et al., 2018).

Second, it would be interesting to consider in future the characteristics of individuals such as their physical characteristics, skills, experience with VR environments and psychological characteristics. These variables are also considered moderate variables of the effects of VR on psychological performance and outcomes. The literature shows that the expected effects of VR

have not always been found precisely because these characteristics are not taken into account (Neumann et al., 2018).

Third, it is important to replicate some of the studies in this dissertation with larger sample sizes and different samples. For example, in Study 4 the “real” self is compared to the “ideal” self. However, the physical difference between these avatars is minimal since the participants in this study do not show high levels of overweight. The possibility of replicating this study with an obese population belonging to a nutrition clinic in Valencia was considered. However, due to the time limitation it has not been possible to carry out the study so far although the design has been made and the study has been approved by the ethics committee of the University of Valencia.

Fourth, to date the “real” self has been compared mainly to the ideal “self”. However, the literature shows that the “future” self can be a promising field in the context of healthy behaviors among which is the PA practice (Hershfield, 2011; Kim & Sundar 2012; Clark et al, 2017; Peña et al., 2020). Therefore, it would be interesting include this self in future studies.

Fifth, taking into account the results found in this dissertation, it seems that the use of avatars with overweight or dissatisfied body population could produce anxiety during the PA practice. As mentioned above, these results were in line with the literature. Song et al. (2014) claimed that the use of avatars in virtual scenarios can elicit anxiety in overweight and body dissatisfied individuals by increasing self-body image awareness. However, it would be interesting to measure this variable at different moments of the PA task in order to analyze how this variable behaves. It would be possible that with prolonged exposure these anxiety levels would decrease and this population could benefit from the use of avatars.

Finally, it would be interesting to include some technological devices that could meausre the movement of the individual's eyes (e.g., eye tracking) while interacting with the VR environment. In this way, it would be possible to analyze what specific characteristic of the avatar's appearance is influencing the outcomes.

5. Conclusions

The main findings regarding the general objectives of this dissertation are presented in the following points:

- The BREQ-2 questionnaire is a useful tool to measure motivation towards PA in the Spanish population. Furthermore, this dissertation confirms once again that motivation towards PA is a variable to be taken into account in order to understand PA behavior due, among other things, to its relationship with other variables that also predict this behavior.
- VR environments are effective in manipulating the feedback received during a PA task and, consequently, its influence on physical and psychological PA responses (e.g., affect, arousal and speed).
- The virtual avatar models can to encourage PA by relying on psychological mechanisms known as social cognitive theory, the Proteus effect and the goal gradient hypothesis. Once again, the importance of customizing avatars used in interventions aimed at increasing PA practice is highlighted (e.g., avatar face).
- The brief online intervention used in this dissertation was effective in increasing PA practice and expectations of self-efficacy in overweight women.
- The manipulation of the body dimensions of avatars does not improve the interventions in overweight women. The use of ideal avatars appears to reduce the anxiety experienced during PA in this population. However, the use of person-like avatars may have a greater impact on PA and related variables in long-term practice.

In summary, on the one hand this dissertation highlights the role of motivation in understanding PA practice behavior. On the other hand, the VR environments used in this dissertation have allowed us to manipulate key aspects that have been shown to have a positive

influence on PA practice (e.g., feedback received during a PA task and avatar customization). Likewise, this dissertation has concluded the effectiveness of a brief online intervention to increase PA practice in overweight and dissatisfied women. Finally, it has shown that manipulating body dimensions in VE in overweight and dissatisfied women may be a useful means to reduce anxiety experienced during PA practice, although it seems that creating user-like avatars may be associated with variables related to the maintenance of PA in the longer term. This dissertation once again supports the use of VR to promote PA practice, as well as the need for further studies to support some of our findings.

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