Estudo sobre o uso de dispositivos tecnolóxicos para a análise e prevención das caídas en residencias de persoas maiores desde unha perspectiva ocupacional

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- Universidade da Coruña (UDC): a través do Grupo de Investigación Redes de Neuronas Artificiales y Sistemas Adaptativos Informática Médica y Diagnóstico Radiológico RNASA-IMEDIR en calidade de coordinador do desenvolvemento do estudo de investigación.
- Clínica Cobián: empresa do ámbito da saúde que foi a principal desenvolvedora da liña de investigación enfocada á incontinencia urinaria.
- Geriatros (actualmente DomusVi): empresa responsable das tres residencias xerontolóxicas onde se levou a cabo o proxecto.
- Aldaba: empresa especializada no eido tecnolóxico que ofreceu unha plataforma dixital propia, específica para o rexistro de datos de saúde, que foi clave para a implementación do proxecto e o estudo de investigación.
- Centro de Investigación en Tecnoloxías da Información e as Comunicacións (CITIC): foi o promotor deste estudo. É o punto de encontro entre a empresa e a universidade, que combina departamentos I+D das empresas xunto cos investigadores da universidade, posibilitando a colaboración e transferencia do coñecemento.

Nesta liña cabe mencionar a transición vivida durante a realización da tese de doutoramento. Aos inicios, a doutoranda foi integrante do Grupo de Investigación RNASA-IMEDIR, un grupo que ten unha ampla traxectoria a nivel autonómico, nacional e internacional. Quero agradecer o acollemento nos meus inicios e a oportunidade brindada de formar parte dun grupo tan recoñecido. Porén, a finais do ano 2019, parte dese grupo encamiñouse a formar un grupo propio, o grupo Tecnoloxía Aplicada á Investigación en Ocupación, Igualdade e Saúde (TALIONIS), enfocado a temas de saúde aplicando innovación tecnolóxica para resolver problemas do día a día de persoas maiores e/ou con diversidade funcional. Ambos os grupos forman parte do CITIC, ao cal debo agradecer as oportunidades e facilidades recibidas ao longo da miña carreira investigadora tanto no desenvolvemento dos proxectos como na divulgación científica.

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A primeira estadía foi realizada desde o 17/05/2018 ata o 17/06/2018 no Instituto Politécnico do Porto en Portugal xunto con António Marques e Cristina Queirós. A devandita estadía foi realizada grazas ao financiamento do Programa IACOBUS. Este é un programa de cooperación interrexional entre as universidades e institucións do ensino superior da Eurorrexión Galicia-Norte de Portugal co apoio da Unión Europea polo Programa INTERREG V-A España-Portugal (POCTEP) 2014-2020.

A segunda estadía foi realizada desde o 30/08/2018 ata o 30/11/2018 na *Health and Wellbeing Priority Research Area* da *Open University* de Reino Unido da que forma parte Hannah Marston. Esta estadía contou co financiamento das axudas para estadías predoutorais INDITEX-UDC 2018. Esta axuda xorde da colaboración entre a UDC coa empresa Inditex, especialmente enfocada na internacionalización dos estudos de doutoramento. Debo agradecer, por tanto, a *Health and Wellbeing Priority Research Area* da *Open University* de Reino Unido e, en especial a Hannah Marston, que foi a responsable da miña estadía durante os tres meses.

Resumo

O risco a caer é unha das síndromes xeriátricas con maior impacto na vida das persoas maiores. Debido á súa complexidade, desde hai décadas conta cun amplo campo de estudo desde diferentes perspectivas e metodoloxías. Existe evidencia de diferentes maneiras de abordar o risco a caer para intentar previr e reducir o seu impacto na saúde das persoas maiores. Dada a relevancia que o risco a caer presenta na vida das persoas maiores e na rutina dos centros xerontolóxicos, a presente tese de doutoramento enfocouse no deseño dun programa multifactorial para lidar con esta problemática. Así, e co fin de afondar máis, a doutoranda decidiu realizar una revisión exhaustiva de experiencias desenvoltas desde a terapia ocupacional que abordasen o risco a caer en persoas maiores a través do uso da tecnoloxía. A literatura existente revelou a presenza de numerosos estudos nos cales foi abordado o risco a caer, pero poucos estudos (n=12) se enfocaron desde a profesión de terapeuta ocupacional no uso de dispositivos tecnolóxicos. En ningún caso, se encontrou algunha experiencia desde esta disciplina que fixesen uso de dispositivos tecnolóxicos para a avaliación das persoas maiores, tendo en conta a relevancia e pertinencia destes dispositivos a día de hoxe. Con base nos resultados obtidos nos tres estudos principais da tese de doutoramento, conclúese que se debe afondar nas achegas que os dispositivos poñibles (ou *wearables)* poden proporcionar para a análise do risco a caer en persoas maiores e, así, tirar conclusións sobre a súa participación ocupacional.

Resumen

El riesgo a caer es una de los síndromes geriátricos con mayor impacto en la vida de las personas mayores. Debido a su complejidad, desde hace décadas cuenta con un amplio campo de estudio desde diferentes perspectivas y metodologías. Existe evidencia de diferentes maneras de abordar el riesgo a caer para intentar prevenir y reducir su impacto en la salud de las personas mayores. Dada la relevancia que el riesgo a caer presenta en la vida de las personas mayores y en la rutina de los centros gerontológicos, la presente tesis de doctorado se enfocó en el diseño de un programa multifactorial para lidiar con esta problemática. Así, y con el fin de ahondar más, la doctoranda decidió realizar una revisión exhaustiva de experiencias desarrolladas desde la terapia ocupacional que abordaran el riesgo a caer en personas mayores a través del uso de la tecnología. La literatura existente reveló la presencia de numerosos estudios nos cuáles fue abordado el riesgo a caer, pero pocos estudios (n=12) se enfocaron desde la profesión de terapeuta ocupacional en el uso de dispositivos tecnológicos. En ningún caso, se encontró alguna experiencia desde esta disciplina que hicieran uso de dispositivos tecnológicos para la evaluación de las personas mayores, teniendo en cuenta la relevancia y pertinencia de estos dispositivos a día de hoy. Con base en los resultados obtenidos en los tres estudios principales de la tesis de doctorado, se concluye que se debe ahondar en las aportaciones que los dispositivos poñibles (o wearables) pueden proporcionar para el análisis del riesgo a caer en personas mayores y, así, tirar conclusiones sobre su participación ocupacional.

Abstract

The risk of falling is one of the geriatric syndromes with the greatest impact on the lives of older people. Due to its complexity, it has been studied for decades from different perspectives and methodologies. There is evidence of different ways of approaching the risk of falling to try to prevent and reduce its impact on the health of older people. Given the relevance that the risk of falling presents in the lives of older people and in the routine of gerontological centres, the present doctoral thesis focused on the design of a multifactorial programme to deal with this problem. Thus, to delve deeper, the PhD candidate decided to conduct an exhaustive review of experiences developed from occupational therapy that addressed the risk of falling in older people using technology. The existing literature revealed the presence of numerous studies in which the risk of falling was addressed, but few studies (n=12) focused on the occupational therapist's profession in the use of technological devices. In no case was any experience found from this discipline that made use of technological devices for the assessment of older people, considering the relevance and pertinence of these devices today. Based on the results obtained in the three main studies of the doctoral thesis, it is concluded that the contributions that wearable devices can provide for the analysis of the risk of falling in older people and, thus, draw conclusions about their occupational participation should be deepened.

Prefacio

Motivación da tese de doutoramento

A iniciativa da presente tese de doutoramento, tal e como se adiantou nos agradecementos, nace do proxecto GeriaTIC, un proxecto financiado polo programa Conecta PEME, no que colaboraron empresas do ámbito sanitario e tecnolóxico, conxuntamente cooperando para a creación dunha solución tecnolóxica encamiñada a reducir e/ou previr as alteracións do sono, o risco a caer e a incontinencia urinaria en persoas maiores que residen en centros xerontolóxicas. Especialmente nesta tese de doutoramento o enfoque céntrase no risco a caer en persoas maiores.

A doutoranda neste período en que o proxecto GeriaTIC deu lugar, obtivo unha axuda do Ministerio de Educación do Goberno de España para colaborar no Departamento de Medicina da UDC, co fin de aventurarse no mundo da investigación e dar apoio ao deseño e posta en marcha do proxecto. Isto xurde mentres a doutoranda realizaba o Mestrado en Asistencia e Investigación Sanitaria, o que tamén foi un requisito indispensable para optar á matriculación no Programa de Doutoramento de TIC no curso académico 2017/2018.

A colaboración da estudante neste proceso de desenvolvemento do proxecto GeriaTIC, espertou o interese en profundar con maior detalle no uso da tecnoloxía por parte de profesionais do ámbito da saúde, especificamente, por terapeutas ocupacionais, para abordar o risco a caer en persoas maiores. O devandito interese enfocouse en afondar nas diferentes formas de actuar sobre o risco a caer a nivel internacional. Esta foi a motivación para decidir ir de estadía a Inglaterra, xunto con Hannah Martson, investigadora que colaborou no proxecto *iStopFalls*, no cal se desenvolveu unha solución tecnolóxica para actuar ante o risco a caer en persoas maiores e que marcou un fito importante na evidencia científica sobre esta temática. No entanto, a doutoranda quixo poñer o foco nas intervencións específicas de terapia ocupacional (TO), xa que encontrou diversos estudos en que esta profesión tiña un papel moi importante para reducir e/ou previr as caídas nas persoas maiores, pero atopou poucas experiencias específicas desde esta profesión que empregasen dispositivos tecnolóxicos.

Esta tese de doutoramento segue as liñas estratéxicas de investigación segundo o novo modelo de vida saudable, concretamente nos seguintes enfoques e obxectivos definidos pola Xunta de Galicia:

- Envellecemento activo: preténdese converter Galicia na rexión líder en Europa na aplicación da tecnoloxía no ámbito do envellecemento activo e da autonomía persoal, e, en especial, para beneficio das persoas maiores afectadas por algunha discapacidade ou condición de saúde específica.
- Prevención, diagnose e tratamento de enfermidades: co fin de continuar a converter Galicia nun referente de vangarda na prevención, diagnose e tratamento das patoloxías.
- Alimentación saudable e segura: céntrase na diversificación do sector alimentario para facer de Galicia un referente internacional da innovación en nutrición e en seguridade alimentaria como chaves para unha vida saudable.

Estrutura e contido da tese de doutoramento

A presente tese de doutoramento divídese nun total de seis capítulos. A continuación, amósase a súa estruturación:

- Capítulo I: expón o marco teórico e os antecedentes en que se fundamentou o desenvolvemento deste traballo, co fin de facilitar a comprensión da investigación levada a cabo.
- Capítulo II: está dedicado á exposición dos diferentes obxectivos alcanzados a través da tese de doutoramento, en función do compendio de artigos que a conforman.
- Capítulo III: amosa de forma resumida a metodoloxía empregada e os resultados obtidos en cada un dos artigos publicados.
- Capítulo IV: céntrase na discusión xeral dos resultados máis resaltables acadados nesta investigación, en comparación coa evidencia científica existente.
- Capítulo V: realza as principais conclusións extraídas da presente investigación xunto coas principais achegas e implicacións prácticas; enúncianse en inglés, pois é un dos requisitos para lograr a mención Internacional da tese de doutoramento. .
- Capítulo VI: é unha listaxe das principais referencias bibliográficas que fundamentaron a tese de doutoramento.
- Nos apéndices están anexadas as copias íntegras de cada un dos artigos publicados que se achegan no presente compendio de artigos.

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Índice de figuras

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Listaxe de abreviaturas

Actividades da vida diaria: AVD.

Clasificación Internacional do Funcionamento, da Discapacidade e da Saúde: CIF.

Escala visual analóxica: EVA.

EuroQol 5D-5L: EQ 5D-5L.

Instituto Nacional de Estatística INE.

Organización Mundial da Saúde: OMS.

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews: PRISMA-ScR.

Programa INTERREG V-A España-Portugal: POCTEP.

Redes de Neuronas Artificiales y Sistemas Adaptativos Informática Médica y Diagnóstico Radiológico: RNASA-IMEDIR.

Rede de Prevención de Caídas de Europa: PROFANE.

Statistical Package for the Social Science: SPSS.

Standard Protocol Items: Recommendations for Interventional Trials: SPIRIT.

Tecnoloxías da información e a comunicación: TIC.

Terapia/terapeuta ocupacional: TO.

Time Get Up and Go: TUG.

Universidade da Coruña: UDC.

Unión Europea: UE.

Capítulo I: Introdución

I.1. Contextualización sociodemográfica da poboación maior

A situación actual que amosa a sociedade desde hai uns anos é o fenómeno do envellecemento progresivo da poboación. Esta situación vese máis acentuada en diferentes países de Europa e Xapón (Daykin *et al.,* 2019; European Commission, 2011; Hewit, 2002).

O envellecemento progresivo da poboación consiste no aumento da proporción das persoas maiores sobre o resto da sociedade. Así, tal e como se pode observar na Figura 1 (Banco Mundial, 2020), o panorama a nivel mundial no ano 1960 é moi diferente ao ano 2020, pois salienta que foi en aumento tanto o número como a proporción de persoas maiores. Por exemplo, Asia pasou de ter unha porcentaxe entre 5,70% e 7,33% de persoas maiores de 65 anos no ano 1960 a ter máis do 13,35%. No caso de Europa, dende o ano 1960, a proporción de poboación de persoas maiores de 65 anos era alta, ao igual que en América do Norte e Oceanía.

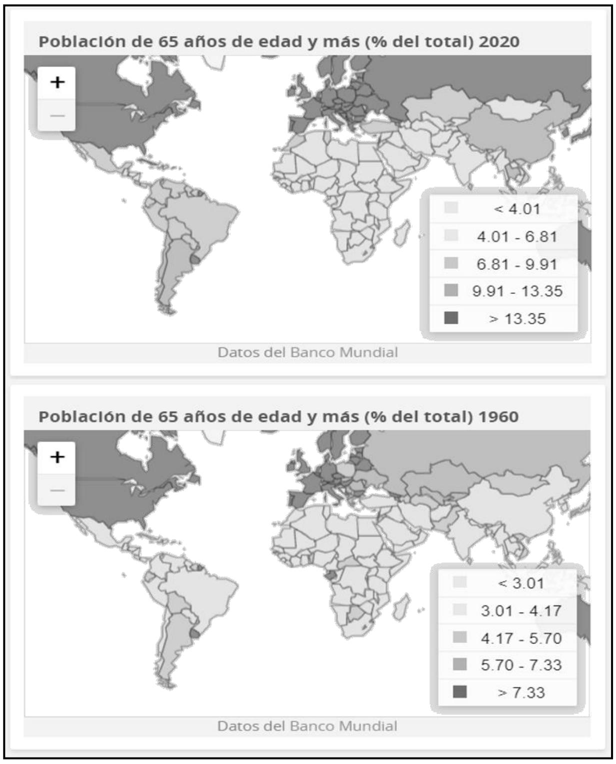

Figura 1: Estimacións do persoal do Banco Mundial sobre a base da distribución por idades/sexo das Previsións Demográficas Mundiais da División de Poboación das Nacións Unidas. Fonte: https://datos.bancomundial.org/

Así e tal e como se reflicte nunha publicación do Eurostat (2020), os habitantes da UE están a vivir máis tempo, situación que se resume en que a proporción de persoas en idade laboral diminúe en comparación coa porcentaxe de persoas maiores. Este padrón seguirá perdurando na nosa sociedade mentres que a xeración dos *baby-boomer*[1] da posguerra complete o seu paso á xubilación.

De acordo ás revelacións en diferentes informes (European Commission, 2021; Eurostat, 2020; OMS, 2011a), é probable que a evolución do envellecemento progresivo da poboación repercuta nos individuos, e tamén sobre os gobernos, as empresas e a sociedade civil, afectando aos sistemas de asistencia sanitaria e social, aos mercados de traballo, ás finanzas públicas e aos dereitos de pensión. Todo isto suscita o interese de enfocar as investigacións nas persoas maiores.

Na actualidade, as persoas maiores representan o 20,3% da poboación europea maior de 65 anos, o cal sitúa Europa detrás de Xapón, o cal ten un 28% de persoas maiores (Daykin *et al.,* 2019; Eurostats, 2019). Nesta liña, os datos máis recentes amosan que as persoas de 60 anos ou máis representan o 23,8% do total da poboación española, e as de 65 anos ou máis o 18,4% (Instituto Nacional de Estatística, 2020). Así, Galicia atópase entre as rexións máis avellentadas de España, tanto en números absolutos como relativos (Abellán *et al.,* 2021; Instituto Galego de Estatística, 2020). Especificamente en Galicia, as persoas maiores de 65 anos representan o 25,5% da poboación, e o número de prazas residenciais dispoñibles por cada 100 persoas maiores sitúase ao redor de 3,1 (Abellán *et al.,* 2021). Asemade, cabe resaltar que o número estimado de persoas maiores que viven en residencias xerontolóxicas en España é do 81,4% (Abellán *et al.,* 2021).

O Instituto Nacional de Estatística (INE) de España (2020) recolle que os homes maiores de 65 anos teñen una esperanza de vida a partir dos 65 de 19,55 anos fronte aos 23,4 anos que teñen as mulleres.

Así, pódese observar que a esperanza de vida está en aumento (OMS, 2020b; Oxford Martin School, 2019), o que significa que se espera que as persoas vivan máis tempo, de modo que aumenta a probabilidade da presenza de enfermidades crónicas e maiores niveis de

[1] Os *baby boomers* son a cohorte demográfica que segue á xeración silenciosa e que precede á xeración X. A xeración defínese xeralmente como as persoas nadas entre 1946 e 1964, durante a explosión de natalidade posterior á Segunda Guerra Mundial. As datas, o contexto demográfico e os identificadores culturais poden variar.

dependencia con respecto ao desempeño ocupacional. Por tanto, a medida que as persoas envellecen, teñen máis demanda do apoio de terceiras persoas, o que complica a viabilidade de envellecer no propio fogar e de forma independente (OMS, 2011a). Neste caso, especialmente en España (Fernández-Carro, 2016), existen tres alternativas principais: vivir na casa con asistencia domiciliaria xa sexa por parte de profesionais ou dunha persoa non profesional, vivir na casa e acudir polo día a un centro de día para persoas maiores e, por último, residir nunha institución.

A institucionalización está caracterizada pola perda de capacidades e habilidades da persoa maior (de Medeiros *et al.,* 2020), o que afecta á súa independencia e autonomía na vida diaria, e dá lugar a un desequilibrio no seu desempeño ocupacional. Así mesmo, existe unha maior propensión a ter unha peor calidade de vida e unha maior deterioración a nivel cognitivo e físico, aspectos que tamén afectan á independencia e autonomía na vida diaria. Nesta liña, o proceso de envellecemento frecuentemente vai acompañado da aparición de condicións da saúde entre as que se encontran as síndromes xeriátricas, incluíndo o risco a caer (Inouye et al., 2007; Riebe et al., 2009; Tuna et al., 2009).

I.2. Prevalencia das caídas en persoas maiores e principais causas e consecuencias

Segundo o INE, Galicia é a comunidade autónoma que encabeza o número de mortes por caídas accidentais, cun total de 397 no ano 2017, seguida de Andalucía, tal e como se amosa na Figura 2 (Instituto Nacional de Estatística, 2020). Estes datos fan referencia á poboación en xeral e non se especifican as razóns específicas. Sen embargo, chama a atención o número de mortes anuais derivadas dunha caída accidental.

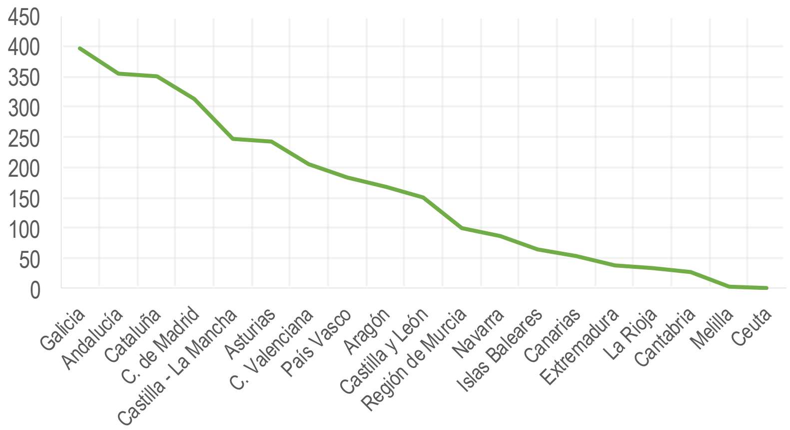

Figura 2: Número de mortes accidentais en España por comunidade autónoma. Fonte: Instituto Nacional de Estatística

As caídas son identificadas como a segunda causa principal de mortes accidentais ou non intencionadas en todo o mundo e o problema máis común e grave a medida que as persoas envellecen (Kannus *et al.,* 2005; Masud & Morris, 2001; McCarter-Bayer *et al.,* 2005; OMS, 2004; United Nations Population Fund & HelpAge International, 2012). O risco a caer considérase un dos motivos relacionados coa diminución do nivel de actividade física e tamén coa institucionalización das persoas maiores. Por este motivo, as caídas identifícanse como un reto sanitario urxente a nivel mundial que, a pesar da situación actual de pandemia, segue cobrando grande importancia, ao igual que é importante manter un nivel óptimo de actividade física (De La Cámara et al., 2020).

Recentes estatísticas identifican que 40.000 persoas maiores morren por razón dunha caída na UE. As persoas maiores de 80 anos ou máis teñen unha mortalidade seis veces maior que o grupo de idade entre 65 e 79, xa que son máis fráxiles. As taxas de mortalidade máis baixas derivadas dunha caída teñen lugar en Bulgaria, España e Grecia (países onde é inferior a 15), mentres que en Hungría, República Checa e Finlandia a taxa é maior a 100 (OMS, 2021).

Segundo as estatísticas da OMS (2021), dado que os principais lugares onde ocorren as caídas son nos domicilios das persoas maiores, é dicir, na súa contorna próxima, resulta de grande importancia a necesidade de crear adaptacións do fogar que liden con esta problemática. As caídas son a segunda causa mundial de morte por traumatismos involuntarios.

A idade é recoñecida como un dos principais factores de risco para experimentar caídas, polo que as persoas maiores son as que corren maior perigo de sufrir unha. Nos Estados Unidos de América, dun 20 a un 30% sofren lesións de moderadas a graves, tales como contusións, fracturas de cadeira e traumatismos craneoencefálicos. A magnitude do risco pode depender dos trastornos físicos, sensitivos e cognitivos relacionados co envellecemento, así como a adaptación da contorna en función das necesidades das persoas maiores (OMS, 2021).

Estudos previos demostraron que o 20% das persoas maiores sofre unha caída anual, que aumenta ata o 50% no caso das persoas de 80 anos ou máis, polo que se converte nunha das principais causas da súa hospitalización (Kannus *et al.,* 2005; Masud & Morris, 2001; McCarter-Bayer *et al.,* 2005; OMS, 2004; United Nations Population Fund & HelpAge International, 2012).

A incidencia de caídas nas persoas maiores de 65 anos que viven na comunidade é de ao redor do 30%, e nos centros de atención residencial, de aproximadamente o 50% (OMS, 2004, 2007). Nesta liña cabe resaltar que nun estudo recente de Burton *et al.* (2018) se mostrou que a incidencia das caídas non cambiou nos últimos dez anos, o cal significa que continúa a ser un tema relevante e pertinente para seguir investigando.

O risco de caídas asóciase a problemas de marcha e equilibrio, que tamén repercuten nos niveis de actividade física. Agmon *et al.,* (2016) demostraron que o aumento da variabilidade da marcha é un forte predictor de caídas na poboación maior. Os problemas da marcha supoñen a perda de independencia, unha redución significativa da calidade de vida, un maior risco de caídas e unha maior mortalidade e morbilidade (Agmon *et al.,* 2016).

Segundo a OMS (2004), os factores intrínsecos das caídas inclúen factores relacionados co proceso de envellecemento que afecta á persoa. Tamén inclúen factores que aumentan o risco de caídas como vivir só, tomar medicamentos (por exemplo, benzodiacepinas) e ter algunhas afeccións médicas (por exemplo, enfermidades cardiovasculares), deterioración da mobilidade e a marcha, comportamento sedentario, medo ás caídas, deficiencias nutricionais, deterioración da cognición, deficiencias visuais e problemas nos pés.

Doutra banda, os factores extrínsecos (OMS, 2004) produćense porque as persoas maiores adoitan ter problemas de esvaraduras ou tropezos, falta de equilibrio ou mecanismos de corrección para evitar as caídas. Entre estes factores atópanse os perigos da contorna, o calzado e a roupa inadecuados, e os dispositivos de axuda para camiñar ou inadecuados. O medo a caer é unha síndrome estreitamente relacionada coas caídas que pode producir unha caída. Ademais, algúns estudos demostraron ou destacan que ao redor dun terzo dos adultos maiores desenvolven o medo ás caídas despois dunha caída (Scheffer et al., 2008; Vellas et al., 1997).

Daquela, é de relevancia destacar que se entende que a caída é un suceso que de forma involuntaria fai perder o equilibrio da persoa e, por tanto, dá lugar a que o corpo acabe no chan ou noutra superficie que sexa firme e que o faga deter (OMS, 2021).

As consecuencias das caídas son diversas, entre elas a redución da calidade de vida e o aumento dos custos socioeconómicos. No caso das primeiras poden incluír unha diminución da mobilidade funcional, un menor nivel de independencia, restricións sociais, depresión, soidade, medo a novas caídas e caídas repetidas. Así, unha das principais consecuencias das caídas é a fractura de cadeira, que se revela como a causa de maior perda de independencia e posible motivo de institucionalización da persoa maior (Cumming *et al.,* 2000; Kerse *et al.,* 2008; Lachman *et al.,* 1998; OMS, 2004; Yardley & Smith, 2002).

I.3. Abordaxe das caídas

Dada a importancia das caídas, é de salientar o labor da Rede de Prevención de Caídas de Europa (PROFANE). Esta é unha rede conformada por 25 socios e está enfocada na prevención de caídas e a mellora da estabilidade postural entre as persoas maiores. O traballo de PROFANE consta dunha serie de tarefas necesarias para desenvolver programas de prevención multifactoriais destinados a reduciren a incidencia de caídas e fracturas entre as persoas maiores. Esta rede centra e coordina os desenvolvementos clínicos, de investigación e desenvolvementos tecnolóxicos europeos en curso relacionados coa prevención de caídas entre as persoas maiores (Prevention of Falls Network Europe, 2011).

Ao consultar a literatura existente pódese observar que diferentes estudos suxiren que os programas multifactoriais son útiles para previr e reducir as caídas debido á complexidade das mesmas (Balzer et al., 2012; Hill et al., 2018).

Segundo a OMS (2004), o risco de caídas aumenta cando existen múltiples factores de risco. Estes programas multifactoriais implican unha combinación de exercicio (centrado na forza, o equilibrio e a mobilidade) e outras opcións como: a avaliación individualizada e exhaustiva do risco de caídas sobre a persoa e a súa contorna e, a educación orientada á prevención de caídas.

O proxecto GeriaTIC é un exemplo do emprego de intervencións multifactoriais para a prevención de caídas. Un estudo duns anos atrás, realizado por Close *et al.,* (1999), xa mencionaba a importancia dun enfoque interprofesional na abordaxe das caídas na poboación maior para poder diminuír significativamente o risco de novas caídas e limitar o impacto funcional.

Segundo datos recentes da OMS (2021), as principais recomendacións e métodos para a prevención de caídas na poboación maior enfócanse en exercicios para mellorar a marcha e o equilibrio, o adestramento funcional, a práctica de Tai Chi, a avaliación da vivenda e modificación do deseño, a redución e eliminación do consumo de psicótropos, e as intervencións multifactoriais, avaliacións individuais do risco a caer, seguidas de intervencións e derivacións médicas en función dos riscos detectados. Tamén sería importante incorporar nos hábitos da persoa o consumo de suplementos de vitamina D para persoas naqueles casos que teñan deficiencia desta vitamina.

De acordo co proceso de envellecemento, as doenzas crónicas poden derivar dunha diminución do nivel de actividade física, extrinsecamente relacionada coa síndrome de risco a caer. Co paso do tempo, algúns estudos concluíron que un maior nivel de actividade física diaria reducía as enfermidades crónicas en todos os grupos de idade. A OMS, (2011b) previamente xa recomendaba aos adultos de 65 anos, entre 150 e 300 minutos de actividade física de intensidade moderada á semana, polo que as intervencións a nivel de actividade física se consideran unhas das máis importantes, tal e como amosan Sherrington *et al.,* (2017).

Como se mencionou anteriormente, as abordaxes das caídas máis recoñecidas deberían incluír un equipo interprofesional e un programa de intervención multifactorial. Dentro do equipo interprofesional, o rol da terapeuta ocupacional é de especial relevancia, xa que consiste nunha profesión socio-sanitaria que promove a saúde das persoas a través da ocupación. Esta abrangue varios aspectos da vida, o que implica diversos métodos de avaliación e intervención. Elliott & Leland, (2018), nunha revisión sistemática, clasificaron as intervencións de terapia ocupacional (TO) sobre as caídas dos adultos maiores en catro tipos diferentes tal e como se amosa na Táboa 1.

Táboa 1: Abordaxe das caídas desde a TO

Tipo de intervención	Características
Un compoñente (inclúe un dos compoñentes indicados á dereita)	• Exercicio • Avaliación da seguridade no fogar • Educación sobre a prevención de caídas Exemplo: Estudo sobre o exercicio funcional integrado no estilo de vida (Clemson *et al.,* 2010)
Intervención multicompoñente (inclúe o exercicio xunto cunha das seguintes opcións)	1.ª opción: intervención educativa 2.ª opción: modificación do fogar Compoñentes complementarios: ▪ Risco para os pés ou o calzado ▪ Estratexias de conservación da enerxía ▪ Uso seguro de dispositivos de axuda, modificación do fogar ▪ Recuperación desde a caída ▪ Manexo da medicación ▪ Nutrición e hidratación ▪ Manexo do estrés Exemplo: exercicio multimodal minimamente supervisado para reducir o risco de caídas en adultos maiores con desvantaxes económicas e educativas (Almeida *et al.,* 2013)
Intervención multifactorial (inclúe a avaliación de diferentes compoñentes)	• Risco a caer • Contorno, educación e actividades grupais • Actividades da vida diaria • Produtos de apoio • Autoeficacia ou medo a caer Exemplo: unha única visita a domicilio dun terapeuta ocupacional reduce o risco de caídas tras unha fractura de cadeira en mulleres de idade avanzada: Un ensaio controlado case aleatorio (Di Monaco *et al.,* 2008).
Prevención de caídas baseada na poboación (inclúe estratexias aplicadas en comunidades enteiras; dous tipos diferentes)	▪ Programas eficaces de prevención de caídas baseados na poboación. ▪ Outras intervencións multicompoñente baseadas na poboación. Exemplo: paso a paso. Tradución dunha intervención de prevención de caídas á práctica: Un ensaio comunitario aleatorio. (Guse et al., 2015)

As persoas cun historial recente de caídas poden collerlle medo a estas. A TO desempeña un papel fundamental á hora de abordar o risco e o medo ás caídas, xa que pode limitar a capacidade dunha persoa para realizar unha ocupación significativa e conducir a un estilo de vida sedentario. Como mencionaron Wu *et al.,* (2020), as/os terapeutas ocupacionais poden colaborar para xestionar as preocupacións da persoa sobre as caídas co obxectivo manter o funcionamento diario e a independencia. Nestas circunstancias, débense buscar novas estratexias e ferramentas para avaliar aspectos relacionados co risco de caídas desde unha perspectiva ocupacional. Por exemplo, o uso de ferramentas tecnolóxicas.

I.4. Tecnoloxías da información e as comunicacións

Ademais dos programas multifactoriais e do equipo interprofesional, está a facerse máis fincapé no uso da tecnoloxía. A tecnoloxía integrouse nalgunhas das intervencións ou enfoques para a redución das caídas (Bailey et al., 2011). Concretamente, a tecnoloxía de asistencia utilizouse para permitir e promover a inclusión e a participación, manter ou mellorar o funcionamento e a independencia, e promover o benestar e a vida activa (Miskelly, 2001; OMS, 2018).

Segundo a OMS (2018), en todo o mundo hai mil millóns de persoas que necesitan produtos de asistencia na actualidade. Espérase que máis de dous mil millóns de persoas en todo o mundo precisen polo menos dun produto de asistencia para o ano 2030. Algúns exemplos do uso da tecnoloxía de asistencia nas intervencións contra as caídas dos adultos maiores poden ser, segundo Miskelly (2001), o seguimento por vídeo, o seguimento da saúde, os sensores electrónicos e equipos como os detectores de caídas, os monitores de portas, as alertas de cama, as alfombras de presión e as alarmas de fume e calor.

No panorama da UE, e lembrando que o exercicio é a abordaxe máis común para previr as caídas das persoas maiores, proxectos europeos anteriores, como iStoppFalls (Marston *et al.,* 2015), Farseeing (Boulton *et al.,* 2016) e Prevent IT (Boulton *et al.,* 2019), centráronse no uso da tecnoloxía para mellorar o funcionamento físico dos adultos maiores. Estes proxectos obtiveron resultados positivos sobre a eficacia do uso de videoxogos para a avaliación e detección das caídas, a creación dunha base de datos sobre sinais para detectar as caídas e o uso da tecnoloxía móbil para a identificación temperá de factores de risco da deterioración funcional das persoas maiores.

A presente investigación céntrase no estudo do uso das tecnoloxías da información e as comunicacións (TIC) por parte das persoas maiores para promover a súa saúde en relación as causas e consecuencias das caídas e, enfocada ao uso de dispositivos *wearable* ou *wearables* para avaliar e/ou reducir os signos e síntomas relacionados coa síndrome de caer. En 2018, o mercado da tecnoloxía *wearable* tiña un valor de case 23.000 millóns de dólares e é probable que creza ata os 54.000 millóns de dólares en 2023, segundo as previsións de GlobalData, (2019), e crecerá a unha taxa de crecemento anual composta do 19% ata 2023.

No ámbito da saúde, as tecnoloxías *wearables* defínense como dispositivos non invasivos e autónomos que capturan, analizan e agregan datos fisiolóxicos para mellorar a saúde e o benestar persoais (GlobalData, 2019). Ata a data, a tecnoloxía *wearable* utilizouse case exclusivamente co fin de estar ben fisicamente, guiada pola crecente demanda dos consumidores por controlaren a súa propia saúde. Os recentes avances están a achegar un valor engadido á asistencia sanitaria, centrándose no diagnóstico, o tratamento, o seguimento e a prevención.

Na comunidade científica existen diferentes experiencias no uso de dispositivos *wearable* en persoas maiores e na poboación en xeral (Tedesco et al., 2017), que inclúen dispositivos coma pulseiras, sensores colocados nos zapatos, na cadeira, entre outros. O patrón de ouro sobre a validez dos datos obtidos por estes dispositivos é a actigrafía (Carson *et al*., 2017), que se toma como referencia para ver a eficacia dos datos doutros dispositivos para a medición da actividade física e o sono, entre outros parámetros fisiolóxicos. Así, o principal uso da tecnoloxía na presente tese enfócase nas oportunidades de avaliación e intervención que poden achegar estes dispositivos e especial a pulseira *Xiaomi.*

Capítulo II: Obxectivos

O obxectivo principal e xeral que se define na presente tese de doutoramento é dar a coñecer unha solución tecnolóxica accesible que axude a previr ou reducir o risco a caer e así promover a calidade de vida, a participación ocupacional e, en definitiva, o envellecemento activo das persoas maiores que residen nunha institución. Para alcanzar o devandito obxectivo, estímase necesario cumprir cos seguintes obxectivos específicos:

- Deseñar un programa de intervención multifactorial que inclúa unha solución tecnolóxica, para previr o risco a caer de persoas maiores que residen nunha institución.
- Afondar nas intervencións realizadas desde terapia ocupacional na abordaxe das caídas en persoas maiores a través do uso da tecnoloxía.
- Estudar e analizar o emprego de dispositivos *wearables* en persoas maiores para a análise da súa actividade física e a súa repercusión no desempeño ocupacional.

Capítulo III: Metodoloxía e resultados

Xustificación e coherencia temática do compendio de artigos

A primeira pregunta que se definiu na presente tese de doutoramento foi: que tipos de avaliacións e intervencións existen na literatura enfocados en persoas maiores que están nunha residencia e que teñen risco a caer? Logo diso, a tese centrouse especificamente na TO e o uso da tecnoloxía, polo que xurdiu a pregunta sobre os tipos de avaliacións e intervencións que se levan a cabo por parte de terapeutas ocupacionais baseándose no uso da tecnoloxía. E, por último, despois de indagar sobre a temática e o resultado das dúas preguntas previas, descubriuse que na literatura se amosa que desde a TO non se están a facer uso de dispositivos wearable. Polo tanto, pretendeuse dar a coñecer esta alternativa para a avaliación do risco a caer nas persoas maiores.

Breve resumo dos artigos do compendio

Estudo 1. Tecnoloxías para a medicina participativa e a promoción da saúde na poboación maior

Como se mencionaba anteriormente, a presente tese de doutoramento xorde do proxecto GeriaTIC. A través do devandito proxecto, deseñouse un protocolo de estudo (estudo 1) sobre a intervención que se ía desenvolver coas persoas maiores participantes, que constaba dunha intervención multifactorial, baseada na colaboración e perspectiva de diferentes profesionais, formando un equipo interdisciplinar, incluíndose terapeutas ocupacionais. Tal proxecto enfócase en tres síndromes xeriátricas: incontinencia urinaria, risco a caer e trastornos no sono. O presente documento céntrase exclusivamente no risco a caer.

Estudo 2: Terapia ocupacional e o uso da tecnoloxía na prevención de caídas en persoas maiores: revisión de alcance

Tras analizar a bibliografía existente durante o desenvolvemento do proxecto GeriaTIC, atopouse que eran escasos os estudos formulados desde a TO e baseados no uso de dispositivos tecnolóxicos para a abordaxe das caídas, polo que isto espertou o interese en realizar unha busca e exploración en maior profundidade desta temática, e acabou dando lugar a unha revisión de alcance (estudo 2), que é a que se presenta nesta tese de doutoramento.

Estudo 3: Análise do risco a caer e a actividade diaria de persoas maiores en residencias en España usando a Xiaomi Mi Band 2

Finalmente, facendo uso dos datos recompilados das persoas participantes no proxecto GeriaTIC, e cos coñecementos acerca das diferentes intervencións tecnolóxicas realizadas por terapeutas ocupacionais nesta temática, realizouse un estudo transversal (estudo 3) sobre o uso de dispositivos wearables para analizar o risco a caer e a actividade diaria das persoas maiores que participan ou residen en centros xerontolóxicos. Neste último estudo, pretendeuse achegar unha nova forma de avaliación para a abordaxe da TO neste ámbito.

III.1. Estudo I. Tecnoloxías para a medicina participativa e a promoción da saúde na poboación maior

Nieto-Riveiro, L., Groba, B., **Miranda, M. C**., Concheiro, P., Pazos, A., Pousada, T., & Pereira, J. (2018). Technologies for participatory medicine and health promotion in the elderly population. *Medicine, 97*(20), e10791. https://doi.org/10.1097/MD.0000000000010791

III.1.1. Metodoloxía

Deseño do protocolo

O protocolo segue as recomendacións *Standard Protocol Items: Recommendations for Interventional Trials* (SPIRIT), que están pensadas para ser unha guía con vistas á elaboración dos protocolos de ensaios clínicos ou similares, nos cales se inclúa unha intervención con participantes humanos co fin de avaliar os seus efectos na saúde das persoas. Neste caso, o estudo é un deseño de series temporais denominado cuase-experimental, que se caracteriza pola ausencia dun grupo control para a comparación dos resultados (SPIRIT Group, 2013).

Ámbito e período de estudo

Este proxecto está enfocado en tres residencias de persoas maiores da provincia da Coruña (España) cunha duración estimada de 30 meses (desde marzo de 2017 ata decembro de 2019).

Perfil de participantes

No proxecto, seleccionáronse tres síndromes xeriátricas (incontinencia urinaria, risco a caer e insomnio ou outros trastornos do sono). Xunto co criterio de ser unha persoa maior de 65 anos, definiuse un perfil de participante en función da síndrome xeriátrica. No caso das persoas con risco a caer, as persoas participantes deberán ter unha historia previa de caídas nos últimos 6 ou 12 meses, experimentar risco e medo a caer, e presentar marcha autónoma. Excluiranse aquelas persoas que empreguen cadeira de rodas.

Intervención

A intervención que se propón neste estudo cuase-experimental consiste no desenvolvemento dun programa multifactorial durante un total de seis meses. En función da síndrome xeriátrica, poden existir pequenas variacións. Especificamente no caso das persoas con risco a caer, os factores que inclúe o programa son:

- Uso dunha pulseira de actividade: durante a duración do programa as persoas participantes deben levar a Xiaomi Mi Band 2 ao longo de todo o día e a noite para analizar a súa actividade física e a calidade do sono de forma diaria.

- Uso dunha aplicación web: neste proxecto deseñouse unha aplicación web para rexistrar as ocupacións e actividades que as persoas realizan no seu día a día co fin de coñecer como son as súas rutinas e hábitos, e posibles cambios ao longo do período de intervención.
- Asesoramento ocupacional sobre o desempeño de actividades diarias: deseñouse un conxunto de recomendacións (en formato texto, acompañadas de imaxes e vídeos) enfocadas en persoas maiores que viven en residencias, para evitar ou reducir posibles riscos como as caídas, ou problemas como a incontinencia urinaria e os trastornos do sono, e mellorar a adaptación da súa contorna física, e a adopción de hábitos de vida saudable.
- Programa de actividade física: seleccionouse o protocolo VIVIFRAIL porque inclúe diferentes exercicios específicos para persoas maiores (Grupo VIVIFRAIL, 2016).
- Programa de relaxación: este programa basearase no método Jacobson.

Recollida de datos

A continuación, amósanse todas as ferramentas de avaliación e variables que se definiron para a realización do estudo e ao final unha breve explicación das ferramentas enfocadas no perfil de persoas con risco a caer.

EuroQol-5D-5L

A EuroQol-5D-5L (EQ-5D-5L) é unha ferramenta que avalía a calidade de vida subxectiva e se centra en catro elementos. O primeiro consiste nun sistema descritivo sobre cinco dimensións: mobilidade (capacidade para camiñar), autocoidado (lavarse ou vestirse), actividades cotiás (é dicir, traballo, estudo, tarefas domésticas, actividades familiares ou de lecer), dor/malestar e ansiedade/depresión. Cada unha destas dimensións pode puntuarse como: (1) ausencia de problemas, (2) presencia de problemas leves, (3) presencia de problemas moderados, (4) presencia de problemas graves ou (5) presencia de problemas / inhabilidades extremas. O segundo elemento é unha escala visual analóxica (EVA), en que a persoa cualifica a súa saúde percibida de 0 (a peor saúde imaxinable) a 100 (a mellor saúde imaxinable). Finalmente, o terceiro e cuarto elemento (o Índice EQ-5D-5L e o Índice de gravidade, respectivamente) son dous índices calculados a partir das puntuacións outorgadas no sistema descritivo. O Índice de gravidade puntúa entre 0 (ausencia de problemas) e 100 (maior gravidade dos problemas), e o Índice EQ-5D-5L entre 0 (estado de saúde similar á morte) e 1 (mellor estado de saúde) (Reenen *et al.,* 2019).

Clasificación Internacional do Funcionamento, da Discapacidade e da Saúde – Conxunto básico de paciente xeriátrico. Versión abreviada.

O conxunto básico da Clasificación Internacional do Funcionamento, da Discapacidade e da Saúde (CIF) é unha ferramenta completa e válida que reflicte os problemas máis relevantes relacionados coa saúde entre a poboación maior que vive na comunidade. Neste caso fixemos uso do conxunto básico de paciente xeriátrico na súa versión abreviada, e unicamente nos enfocamos en actividades e participación, e factores ambientais. Actividades e participación puntúanse como 0, 1, 2, 3, ou 4 (segundo a ausencia ou presencia de "deficiencias" ou dificultades de menor ou maior intensidade), ou incluso como 8 no caso de que o ítem non se poida especificar, ou 9 se non é aplicable. En cambio, as categorías ou ítems pertencentes ao compoñente de Factores ambientais, puntúanse nunha escala como +4, +3, +2, +1 (no caso de factores ambientais que actúen como facilitadores nas actividades e participación da persoa), 0 (no caso de aqueles factores que sexan neutros), -1, -2, -3, -4 (no caso de factores ambientais que actúen como barreiras), ou 8 ou 9 (para aqueles factores que non poidan especificar ou que non sexan aplicables) (Grill *et al.,* 2011; OMS, 2020a).

Índice de Barthel de Actividades da Vida Diaria

O Índice de Barthel de Actividades da Vida Diaria (AVD) utilizouse como un sinxelo índice de independencia para puntuar a capacidade da persoa para coidarse a si mesma e, repetindo a proba periodicamente, avaliar a súa evolución. O rendemento avalíase con base nestas puntuacións: <20= dependencia total, 20 a 40= dependencia severa, 45 a 55= dependencia moderada, e 60 ou máis= dependencia leve. Esta ferramenta utilízase nas avaliacións inicial, continuada e final (Wade & Collin, 1988).

Escala Tinetti: equilibrio e marcha

A Escala Tinetti é unha proba que mide a marcha e o equilibrio dunha persoa. Puntúase segundo a capacidade da persoa para realizar tarefas específicas. A puntuación da ferramenta de avaliación de Tinetti realízase nunha escala ordinal de 3 puntos cun rango de 0 a 2. Unha puntuación de 0 representa a maior dificultade, mentres que unha puntuación de 2 representa a independencia. As puntuacións individuais combínanse para formar tres medidas: unha puntuación global de avaliación da marcha, unha puntuación global de avaliación do equilibrio e unha puntuación combinada da marcha e o equilibrio. Esta ferramenta utilízase nas avaliacións inicial, continuada e final; mide o risco a caer en función da marcha e o equilibrio, e dá a posibilidade de obter un total de 28 puntos, de modo que > 24 indica que a persoa non ten risco a caer e ≤ 24 indica que a persoa ten risco a caer, sendo baixo este risco se a puntuación está entre 19 e 24 puntos, e alto se a puntuación é inferior a 19 puntos (Tinetti et al., 1986).

Mini-Mental State Examination

O *Mini-Mental State Examination* é unha ferramenta deseñada para determinar o "estado cognitivo", que é unha das variables do estudo. Utilizarase no cribado para verificar un dos criterios de exclusión establecidos e nas avaliacións inicial, continuada e final. Presenta seis valores, un por cada apartado: Orientación, Fixación, Concentración e cálculo, Memoria e Linguaxe e Construción) e puntuación final (Folstein et al., 1975). As puntuacións de referencia son que ≥ 27 o estado cognitivo é normal, ≤ 24 é sospeita de deterioro cognitivo, entre 12-24 existe deterioro cognitivo, e entre 9-12 identifícase que a persoa ten demencia.

Índice de Comorbilidade de Charlson

O Índice de Comorbilidade de Charlson é un índice útil para predicir a supervivencia a 10 anos en persoas con múltiples comorbilidades. Consta de 19 ítems, que si están presentes, inflúen soa a esperanza de vida (Charlson et al., 1987).

Time Get Up and Go

O *Time Get Up and Go* (TUG) é unha proba que se utiliza para avaliar a mobilidade dunha persoa que require equilibrio estático e dinámico, e é útil para identificar a existencia ou non do risco a caer. Mide o tempo que tarda unha persoa en levantarse dunha cadeira, camiñar tres metros, darse a volta, volver á cadeira e sentarse. Durante a proba, espérase que a persoa leve o seu calzado habitual e utilice calquera axuda para a mobilidade que necesite normalmente (Podsiadlo & Richardson, 1991). En primeiro lugar a persoa debe facer un intento de práctico e logo debe facer 3 intentos nos que se cronometrará o tempo que lle leva levantarse da cadeira, camiñar 3 metros, dar a volta e sentarse na cadeira. Faise unha media deses 3 intentos e a interpretación sería: < 10 segundos significa mobilidade independente, < 20 segundos significa maiormente independente, entre 20-29 segundos sería mobilidade variable, e > 20 segundos sería mobilidade reducida.

Falls Efficacy Scale - International

A *Falls Efficacy Scale – International* (FES-I) é unha ferramenta breve e fácil de administrar que mide o nivel de preocupación polas caídas durante as actividades sociais e físicas dentro e fóra do fogar, independentemente de que a persoa realice ou non a actividade. O nivel de preocupación mídese nunha escala de Likert de 4 puntos (sendo 1 = ausencia de preocupación a 4 = moita preocupación) (Delbaere *et al.,* 2010).

Avaliacións específicas do risco a caer

As avaliacións específicas do risco a caer, a TUG e a FES-I, para medir a eficacia do programa multifactorial aplicaranse na fase de avaliación inicial, antes da intervención, e combináranse con avaliacións periódicas ou de seguimento, nas fases de avaliación continuada e final, xunto coas demais ferramentas. Así, realizarase unha avaliación final xusto ao remate da intervención, e outra aos tres meses.

Análise de datos

A análise dos datos realizarase co programa estatístico *Statistical Package for the Social Science* (SPSS). As variables cuantitativas expresaranse coa media e a desviación estándar, mentres que as variables cualitativas se expresarán en valor absoluto e porcentaxe.

Para comparar as medias utilizarase a proba *t de student* e para as comparacións múltiples de medias utilizarase a análise da varianza. Esta proba permite determinar se as diferenzas entre os valores de ambas as variables son estatisticamente significativas ou se son diferenzas debidas ao azar. Para estudar a asociación entre as variables cualitativas, utilizarase a proba x2.

Doutra banda, para determinar as variables que se asocian ou non á presenza da variable dicotómica de interese (calidade de vida), realizarase unha análise de regresión loxística multivariante, utilizando como variable dependente a presenza ou non do evento de interese, e como covariables, as variables que na análise bivariante se asocien á presenza do devandito evento ou que sexan clinicamente relevantes.

Temporalización do estudo

Os instrumentos utilizados no estudo e os tempos específicos para a avaliación e intervención están especificados na Figura 3.

Figura 3: Cronograma do protocolo de estudo

III.2. Estudo II. Terapia ocupacional e o uso da tecnoloxía na prevención de caídas en persoas maiores: revisión de alcance

Miranda-Duro, M., Nieto-Riveiro, L., Concheiro-Moscoso, P., Groba, B., Pousada, T., Canosa, N., & Pereira, J. (2021). Occupational Therapy and the Use of Technology on Older Adult Fall Prevention: A Scoping Review. International Journal of *Environmental Research and Public Health, 18*(2), 702. https://doi.org/10.3390/ijerph18020702

III.2.1. Metodoloxía

En xaneiro de 2020, levouse a cabo unha revisión de alcance que estaba enfocada a resolver a seguinte pregunta de investigación: que se sabe sobre o alcance, tipos de estudos e abordaxes e estratexias para o risco a caer usando a tecnoloxía na literatura existente de TO tendo en conta as intervencións desempeñadas para abordar os efectos das caídas nas persoas maiores no seu día a día?

Utilizáronse dúas abordaxes para o desenvolvemento desta revisión de alcance, e a selección e análise dos resultados. Por unha banda, empregouse o marco de cinco fases definido por Arksey & O'Malley (2005):

1. Establecemento da pregunta de investigación.
2. Identificación dos estudos pertinentes ou relevantes.
3. Selección dos estudos: identificación, avaliación, elixibilidade e inclusión final.
4. Resumo e análise dos datos.
5. Organización, resumo e comunicación dos resultados.

Doutra banda, esta revisión de alcance tamén seguiu as recomendacións de *Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews* (PRISMA-ScR) (Tricco *et al.,* 2018). De acordo co obxectivo dunha revisión de alcance, non se require unha avaliación de calidade, a diferenza das revisións sistemáticas e as metaanálises.

A procura centrouse en sete bases de datos electrónicas, especificamente en bases de datos do eido das ciencias da saúde e a TO: Biblioteca Virtual de Saúde España, CINAHL, Cochrane Plus, OTSeeker, PubMed®, Scopus e Web of Science. Os criterios utilizados foron flexibles por tratarse dun tema de actualidade. Os criterios de elixibilidade foron artigos escritos en inglés, portugués e/ou español; non houbo límite no ano de publicación; os estudos só podían involucrar seres humanos; e consideráronse todos os tipos de documentos (é dicir, artigos orixinais, revisións e documentos de conferencias). Para cada base de datos, utilizáronse estratexias de procura individuais combinando os operadores "AND" e "OR", xunto cos criterios definidos e os seguintes descritores:

- occupational therapy, ergotherapy;
- falls, accidental falls;

- aged, geriatrics, gerontology, older adult, older person, elder person, older people, elderly, elderly people, veteran, retired, senior;
- technology, technologies, wearable electronic devices, wearables, computers, digital games.

Tras a procura, e de acordo coas directrices PRISMA-ScR, o primeiro paso foi a identificación de todos os rexistros, que se importaron ao xestor bibliográfico *Mendeley*. O segundo paso foi o cribado, mediante o cal se eliminaron as duplicacións a través do mesmo xestor. No paso de elixibilidade, os resultados foron avaliados primeiro por título, segundo por resumo e, por último, por texto completo. Seguíronse os criterios de elixibilidade definidos e de acordo co tema de interese: intervencións de TO baseadas na tecnoloxía para abordar as caídas nas persoas maiores. Por tanto, os estudos debían incluír as caídas, a poboación maior, unha perspectiva de TO e o uso da tecnoloxía. En total, 12 traballos cumpriron os criterios definidos. No material complementario do artigo publicado, amósase todo o proceso levado a cabo en maior detalle, así como o listado dos artigos das procuras coas razóns de rexeitamento ou aceptación.

III.2.2. Resultados

Os resultados están conformados por un total de 12 artigos científicos que cumpriron cos criterios previamente citados e deseñados, tras pasar unha rigorosa análise. Nos apéndices, no texto completo do artigo publicado, pódese consultar a táboa coas características de cada estudo incluído nesta revisión de alcance.

Os resultados están divididos entre as características bibliométricas (ano de publicación e localización xeográfica, ámbito das revistas científicas, e tipos de estudo), e as temáticas (participantes dos estudos, tipos de intervencións e abordaxe das caídas, e tipos de tecnoloxía).

Ano de publicación e localización xeográfica

En canto ás características bibliométricas, destáca que os resultados foron publicados entre os anos 2012 e 2020. Desta forma, o primeiro artigo en que se inclúe a tecnoloxía como parte da intervención da TO para abordar as caídas, rolda o ano 2012 (Chase et al., 2012). Asemade, en relación coa localización xeográfica, os estudos encontráronse en países de Europa (n=6) (Glännfjord et al., 2017; Hamm et al., 2017, 2019; Lemmens, R; Gielen, C; Spooren, 2017; Money et al., 2019; Stewart & McKinstry, 2012), Estados Unidos (n=4)

(Arthanat et al., 2019; Charness, 2014; Chase et al., 2012; Horowitz, Nochajski, & Schweitzer, 2013); e outros estudos en Tunisia (n=1) (Ben Haj Khaled et al., 2020) e Australia (n=1) (Lo Bianco et al., 2016).

Ámbitos das revistas científicas

Dentro dos tipos de revistas en que se publica sobre a temática atopamos que 6 dos 12 estudos foron publicados en revistas enfocadas na TO coincidindo coas primeiras publicacións (Arthanat *et al.,* 2019; Charness, 2014; Chase *et al.,* 2012; Horowitz, Nochajski, & Schweitzer, 2013; Stewart & McKinstry, 2012), mentres que os outros 6 están en revistas informáticas e tecnolóxicas, coincidindo coas publicacións máis recentes (Ben Haj Khaled *et al.,* 2020; Hamm et al., 2017, 2019; Lemmens, R; Gielen, C; Spooren, 2017; Lo Bianco *et al.,* 2016; Money *et al.,* 2019).

Tipos de estudos

Os tipos de estudos analizados son unha revisión sistemática (Chase *et al.,* 2012), unha revisión crítica (Stewart & McKinstry, 2012) e os 10 restantes (Arthanat *et al.,* 2019; Ben Haj Khaled *et al.,* 2020; Charness, 2014; Glännfjord *et al.,* 2017; Hamm *et al.,* 2017, 2019; Horowitz, Nochajski, Schweitzer *et al.,* 2013; Lemmens, R; Gielen, C; Spooren, 2017; Lo Bianco *et al.,* 2016; Money *et al.,* 2019) son artigos orixinais que inclúen estudos descritivos, estudos de casos e estudos experimentais, estudos cualitativos e estudos mixtos.

Participantes dos estudos

Nesta categoría temática, inclúense os perfís de participantes, a idade, a porcentaxe de mulleres e homes, a contorna onde se desenvolveu o estudo (na comunidade ou nunha institución) e outra información de interese sobre as persoas participantes nos estudos analizados.

A revisión de Chase *et al.,* (2012) inclúe un total de 33 estudos mentres que a revisión de Stewart & McKinstry (2012) inclúe un total de 10. Ningunha destas revisións analiza as características dos/as participantes.

Os artigos orixinais (Arthanat *et al.,* 2019; Ben Haj Khaled *et al.,* 2020; Charness, 2014; Glännfjord *et al.,* 2017; Hamm *et al.,* 2017, 2019; Lemmens, R; Gielen, C; Spooren, 2017; Lo Bianco *et al.,* 2016; Money et al., 2019; Stewart & McKinstry, 2012) inclúen desde persoas maiores, un total de 614, a profesionais ou outras persoas da súa contorna próxima (15 terapeutas ocupacionais, e 5 persoas coidadoras informais). O tamaño da mostra abrangue dende 1 persoa ata 445 persoas maiores, de 1 a 10 terapeutas ocupacionais, e de 1 a 5 persoas coidadoras informais.

A idade inclúe un rango desde os 50 anos como mínimo ata un máximo de 98 anos. As persoas foron escollidas en distintas contornas: na comunidade, en centros para persoas maiores, ou persoas que acoden a un grupo de ximnasia nun campus universitario.

A porcentaxe de mulleres nas mostras dos estudos está entre o 60 e o 68% do total, sendo en todas as investigacións superior á proporción de homes. Porén, no caso das terapeutas ocupacionais, o 100% eran mulleres.

Tipos de intervencións e abordaxe das caídas

Esta categoría temática inclúe o tipo de intervención se o estudo trata sobre un factor de risco específico relacionado coas caídas (extrínseco, alleo ao individuo, ou intrínseco, relacionado coa persoa e o seu proceso de envellecemento, ou con outras condicións persoais) e o tipo de enfoque de abordaxe das caídas (detección, prevención ou tratamento).

Identificáronse catro tipos de intervención: "modificacións do fogar" (n = 5) (Hamm *et al.,* 2017, 2019; Horowitz, Nochajski, Schweitzer *et al.,* 2013; Lemmens, R; Gielen, C; Spooren, 2017; Lo Bianco *et al.,* 2016); "tecnoloxía de asistencia" (n = 4) (Arthanat *et al.,* 2019; Charness, 2014; Chase *et al.,* 2012; Stewart & McKinstry, 2012); "exercicio" (n = 2) (Ben Haj Khaled *et al.,* 2020; Glännfjord *et al.,* 2017); e "intervencións educativas" (n = 2) (Horowitz, Nochajski, Schweitzer *et al.,* 2013; Money *et al.,* 2019). Consideráronse as intervencións dun só compoñente e centráronse na detección, a prevención e o tratamento das caídas.

As intervencións que se centraron nas "modificacións do fogar" abordaron factores extrínsecos como son as modificacións do baño (é dicir, a bañeira, o inodoro ou a ducha), a altura adecuada da cadeira e as indicacións para incluír espazo para moverse, entre outras.

As intervencións de tecnoloxía asistencial abordaron factores extrínsecos que poden afectar á seguridade da persoa no fogar. Isto incluía o uso de teleasistencia, alarmas de emerxencia e detectores de caídas (é dicir, alarmas colgantes).

O "exercicio" utilizouse como estratexia para abordar os factores intrínsecos relacionados coa condición física.

E as intervencións educativas nestes estudos baseouse nos factores extrínsecos, que consistían nos tipos de modificación que a persoa ten que facer para estar segura na casa.

Tipos de tecnoloxía

Esta categoría temática refírese aos tipos de tecnoloxía abordados nos estudos cuxo resumo se amosa na Táboa 2. As tecnoloxías utilizadas nos estudos clasificáronse como: desenvolvementos de software, telesaúde, materiais multimedia e dispositivos comerciais e tecnolóxicos.

Os desenvolvementos de software (n=5) incluían aplicacións de realidade aumentada (Lo Bianco *et al.,* 2016), aplicacións prototipo de axuda á medición en 3D (Hamm *et al.,* 2017, 2019), unha versión dixital da ferramenta Obstacles (Lemmens, R; Gielen, C; Spooren, 2017) e un xogo 3D Falls Sensei (Money *et al.,* 2019).

O uso da telesaúde integrouse na teleasistencia para reducir o medo ás caídas (Stewart & McKinstry, 2012) e o sistema integrouse nun reloxo para proporcionar un sistema de sensores de factores para controlar a temperatura cunha pantalla analóxica, un botón de emerxencia e un acelerómetro (Charness, 2014).

Os materiais multimedia (Horowitz, Nochajski, Schweitzer *et al.,* 2013) incluían diferentes vídeos para identificar os factores ambientais das caídas.

Os dispositivos comerciais e tecnolóxicos incluían tecnoloxía doméstica intelixente para manexar as luces, os electrodomésticos, as portas e as xanelas (Chase *et al.,* 2012) e estes incluían o uso de Kinect (Ben Haj Khaled *et al.,* 2020) e Nintendo Wii (Glännfjord *et al.,* 2017).

Táboa 2: Resumo dos tipos de intervencións e a tecnoloxía utilizada

Intervención	Factores de risco a caer	Tecnoloxía utilizada	Compatibilidade
Modificacións do fogar	Factores extrínsecos	Aplicación de realidade aumentada	iPad
		Aplicación 3D	Tablet, móbil, ou ordenador portátil
		Versión dixital da ferramenta Obstacle	Tablet
		Xogo Falls Sensei 3D	Ordenador
Tecnoloxía de asistencia	Factores extrínsecos	Sistema de telesaúde	Non aplicable
		Telesaúde	
		Fogar intelixente	
Intervencións educativas	Factores extrínsecos	Material multimedia	Ordenador
Exercicio	Factores intrínsecos	Dispositivos comerciais	Kinect con Xbox e Nintendo Wii

III.3. Estudo III. Análise do risco a caer e a actividade diaria de persoas maiores en residencias en España usando a Xiaomi Mi Band 2

Miranda-Duro, M., Nieto-Riveiro, L., Concheiro-Moscoso, P., Groba, B., Pousada, T., Canosa, N., & Pereira, J. (2021). Analysis of Older Adults in Spanish Care Facilities, Risk of Falling and Daily Activity Using Xiaomi Mi Band 2. *Sensors* (Basel, Switzerland), *21*(10), 3341. https://doi.org/10.3390/s21103341

III.3.1. Metodoloxía

O presente artigo consistiu nun estudo observacional, transversal e descritivo levado a cabo en tres centros xerontolóxicos localizados na comunidade autónoma de Galicia (España), que son residencias que contan tamén co servizo de centro de día. Este estudo forma parte do proxecto GeriaTIC e realizouse desde marzo do ano 2017 ata decembro do ano 2019.

A mostra estivo conformada por persoas maiores de 65 anos, con capacidade para camiñar tres metros de maneira autónoma. Ademais, incluíronse a persoas que: puidesen prover de forma escrita o consentimento; entendesen, falasen e lesen en español e/ou galego; non tivesen aceptada un traslado a outra residencia, e aceptasen ter posta a pulseira *Xiaomi Mi Band* 2 durante 30 días (ao longo de todo o día e a noite).

Recollida de datos

As persoas maiores participantes neste estudo tiveron que levar a pulseira de rexistro de actividade Xiaomi Mi Band 2 durante 30 días, ao longo das 24 horas do día. As ferramentas de avaliación seleccionadas, que se explican a continuación, administráronse o primeiro día de uso desta pulseira de rexistro de actividade.

Ferramentas e medidas

Consulta na base de datos da institución

As variables demográficas e socio-sanitarias seleccionadas foron: o sexo (home ou muller), a idade, o centro asistencial do que era usuaria cada persoa (residencia ou centro de día), o estado civil (viuvez ou non), o índice de masa corporal, e o número de diagnósticos procedentes da historia clínica.

Outras variables incluídas foron o número de produtos de apoio non específicos da mobilidade (lentes, audiófonos ou almofada antidecúbito), o número de axudas á mobilidade (bastón, muletas ou andador), o número de caídas nos últimos 12 meses, e o perfil de clasificación das caídas (non caedor con algunha caída nos últimos 12 meses ou caedor cunha ou máis caídas nos últimos 12 meses).

Ademais, da base de datos da institución colleuse a puntuación máis recente do Índice de Barthel, e da Escala de Tinetti, e a presenza ou non de deterioración cognitiva.

O Índice de Barthel mide o nivel de dependencia ou independencia na execución das AVD (como a alimentación, o baño ou ducha, o aseo, o vestido, o control dos esfínteres, o control da vexiga, o uso do inodoro, as transferencias, a mobilidade en superficies planas, e a subida e baixada das escaleiras). No Índice de Barthel a puntuación oscila entre 0 e 100 puntos; 100 considérase independencia total nas AVD, e >100 significa calquera nivel de dependencia en AVD (Wade & Collin, 1988).

A Escala de Tinetti avalía o risco de caída con base na marcha e o equilibrio, e a puntuación total está entre 0 e 28, considerando ≤ 24 como ausencia de risco de caída e > 24 como risco de caída (Tinetti *et al.*, 1986).

Calidade de vida relacionada coa saúde

Utilizouse o EQ-5D-5L para explorar a percepción subxectiva de cada participante sobre a súa calidade de vida. Esta ferramenta avalía catro elementos. O primeiro consiste nun sistema descritivo de cinco dimensións: mobilidade (capacidade de camiñar), coidado persoal (lavarse ou vestirse), actividades cotiás (é dicir, traballo, estudo, tarefas domésticas, actividades familiares ou actividades de lecer), dor/malestar e ansiedade/depresión. Estas cinco dimensións avalíanse en 5 posibles niveis de gravidade: (1) ausencia de problemas, (2) presencia de problemas leves, (3) presencia de problemas moderados, (4) presencia de problemas graves, ou (5) presencia de problemas/ inhabilidades extremas. Nesta investigación, diferenciouse para a análise estatística entre aqueles casos que tiñan algún problema, independentemente do nivel de intensidade deses problemas, e aqueles casos que non presentaban ningún problema. O segundo elemento é unha EVA en que a persoa cualifica a súa saúde percibida de 0 (a peor saúde imaxinable) a 100 (a mellor saúde imaxinable). Por último, o terceiro e o cuarto elemento (o Índice EQ-5D-5L e o Índice de Gravidade, respectivamente) son dous índices calculados a partir das puntuacións outorgadas nas cinco dimensións que conforman o sistema descritivo. O Índice de Gravidade puntúa entre 0 (ausencia de problemas) e 100 (maior gravidade), e o Índice EQ-5D-5L entre 0 (estado de saúde similar á morte) e 1 (mellor estado de saúde) (Grill *et al.,* 2011; OMS, 2020a).

Xiaomi Mi Band 2

Fíxose seguimento das persoas maiores participantes durante 30 días coa *Xiaomi Mi Band 2* situada na súa man dominante. Este dispositivo ten unha batería duns 30 días, polo que non foi necesario recargala durante o período de estudo. Utilizouse para contar os pasos co fin de proporcionar un medio para cuantificar obxectivamente a actividade diaria total. Creáronse contas individuais de *Gmail* para cada participante, para poder crear a continuación contas individuais na aplicación móbil *MiFit* (dispoñible para a súa descarga gratuíta en dispositivos Android desde a Play Store), co fin de recoller nesta aplicación os datos recompilados polas pulseiras e, poder extraelos posteriormente a un documento de *Excel*. Os parámetros obtidos foron as medias de 30 días baseados nas seguintes variables:

- Actividade diaria: foi analizada a través do número de pasos diarios e a distancia diaria percorrida por cada participante en metros. En base ao estudo de Tudor-Locke *et al.,* (2011), determinouse que <3000 pasos indicaban un nivel baixo de actividade física e 3000-10.000 pasos indicaban un nivel de actividade física moderada.
- Sono: analizouse en minutos en catro parámetros diferentes (sono profundo diario, sono superficial diario, sono total diario e tempo esperta/o na cama durante a noite). Utilizouse a recomendación da Fundación do Sono (2021) para referenciar o sono adecuado das persoas adultas maiores ao redor de 7-8 horas, o que corresponde a 420-480 minutos ao día.

Os datos das pulseiras foron contrastados por profesionais de cada institución e do equipo de investigación, preguntando semanalmente ás persoas participantes sobre o seu sono e actividade diaria para asegurarse de que os datos representaban a súa vida cotiá. Así mesmo, se a aplicación móbil *MiFit* mostraba valores nulos nalgún período de tempo, isto significaba que a persoa non levara a pulseira durante ese período, ou mesmo que o dispositivo estaba a fallar. Neste estudo, profesionais de cada institución supervisaron se o/a participante levaba a pulseira a diario.

Análise estatística

A análise estatística realizouse a través do programa *SPSS*. En primeiro lugar, realizouse unha análise descritiva calculando as medias e a súa desviación estándar, ou frecuencias e porcentaxes, segundo o tipo de dato.

En canto á análise inferencial, no caso de dúas variables categóricas, aplicouse a proba de khi cadrado, contrastada coa proba de Fisher, xa que máis do 20% das celdas tiñan valores inferiores a 5. Por estas razóns, as variables categóricas agrupáronse en dous valores diferentes para crear táboas de continxencia 2×2. O tamaño do efecto comprobouse co V de

Cramer, que ten valores entre 0 e 1, polo que os valores próximos a 1 indicaban unha forte asociación.

Por outra banda, a normalidade das variables numéricas analizouse coa proba de *Shapiro-Wilk*, que está pensada para mostras pequenas. As variables cunha distribución normal (proba de *Shapiro-Wilk* con $p > 0,05$) analizáronse coa *proba t de Student* (probada en cada variable categórica) e a correlación de *Pearson* (correlación con outras variables numéricas), e as que tiñan unha distribución anormal (proba de *Shapiro-Wilk* con $p < 0,05$) analizáronse coa proba de correlación de *Spearman* (correlación con outras variables numéricas) e a proba U de *Mann-Whitney* (variables numéricas con distribución anormal e variables categóricas). O coeficiente "rho" de *Spearman* e *Pearson* (valores de 0 a 1) determinou a magnitude da correlación, e para os resultados da proba U de *Mann-Whitney* utilizouse o programa informático *GPower* 3.1. para calcular o tamaño do efecto (a magnitude estimada da relación) e a potencia estatística (a probabilidade de que se acepte a hipótese nula cando a hipótese alternativa é verdadeira) das correlacións e asociacións segundo o *g* de *Hedges*, que se indicou con "*g*" e a potencia estatística con "β". Entón, os valores de *g* inferiores a 0,2 indicaban un tamaño do efecto pequeno, valores de 0,5 representaban unha magnitude media e valores de 0,8 indicaban un efecto de magnitude alta.

Con respecto ás asociacións significativas exploradas previamente, as asociacións de risco de caída e os parámetros da *Xiaomi Mi Band* 2 analizáronse mediante regresións binarias simples, co fin de determinar as razóns de probabilidade ou *odds ratios,* xa que as variables dependentes son categóricas e toman dous valores (0, 1). Os valores de R^2 de *Cox e Snell* e de R^2 de *Nagelkerke* indican a porcentaxe en que a regresión explica a relación entre as variables. Cando o valor é superior a 0,4, o 40% da regresión explica a asociación entre as variables. Pode considerarse polo tanto un bo resultado.

Por último, decidiuse aplicar un modelo xeneralizado desenvolto con distribución Gamma e ligazón logarítmica. Este tipo de modelo utilízase para variables que non teñen unha distribución normal e teñen un número enteiro e valores positivos, como nos pasos diarios.

Aspectos éticos

O presente estudo seguiu as consideracións éticas da Declaración de Helsinqui para a ética da investigación en seres humanos. Ademais, garantiuse o anonimato das persoas participantes e a confidencialidade dos seus datos segundo o Regulamento 2016/679 e a derrogación da Directiva 95/46/E. C. do Parlamento Europeo para a protección de datos persoais. Os participantes recibiron información completa verbal e escrita (mediante a Folla de información a participantes) sobre as características do estudo e as implicacións derivadas da súa participación nel. Unha vez que se comprobou que todas as persoas participantes comprendían perfectamente a información proporcionada, aceptaron participar no estudo mediante o Documento de consentimento informado. Os seus datos foron recollidos e conservados ata o final do estudo en modo codificado.

III.3.2. Resultados

Incluíronse no estudo un total de 31 adultos maiores. Como se indica na Táboa 3, a idade media era duns 84 anos. Tamén houbo homoxeneidade no sexo, de modo que as mulleres representaron o 51,6% da mostra e os homes o 48,4% restante. A mostra deste estudo residía maioritariamente nunha residencia de maiores (n=28) e o estado civil predominante era a viuvez (83,9%); ademais, a maioría de persoas tiñan sobrepeso (71%), presentaban problemas asociados a algunha condición física (54,8%) (por exemplo: osteoporose, artrose, mareos e vertixes, artrite reumatoide, anomalías da marcha e a mobilidade, ou esclerose múltiple), con presenza de deterioración cognitiva (64,35%), con algún nivel de dependencia nas actividades básicas da vida diaria. (77,4%), con risco a caer (67,7%) realizaban menos de 3.000 pasos ao día (87,1%), durmían menos de 420-480 minutos ao día (54,83%), utilizaban produtos de apoio para a mobilidade (41,9%) e valoración do estado de saúde inferior a 50 sobre 100 (12,9%). Así mesmo, durante o estudo, se algún participante sufriu unha caída, esta variable non se analizou.

Táboa 3: Características predominantes das persoas participantes

Característica	N (%) / Media (±DS)
Idade	84 (±8,71)
Muller	16 (51,6%)
Residente nunha institución	28 (90,3%)
Viuvez	28 (83,9%)
Presenza de sobrepeso	22 (71%)
Problemas físicos	17 (54,8%)
Deterioración cognitiva	20 (64,5%)
Dependencia nas actividades básicas da vida diaria	24 (77,4%)
Risco a caer	21 (67,7%)
Menos de 3.000 pasos diarios	27 (87,1%)
Sono entre 420-480 minutos diarios	17 (54,83%)
Uso de produtos de apoio para a mobilidade	13 (41,9%)
EQ-5D-5L VAS < 50	26 (12,9%)

Historial de caídas

O historial de caídas expresa o número de caídas experimentadas nos últimos 12 meses previos ao comezo do presente estudo. Obtívose que o 45,2% da mostra (n=14) tivo caídas nos últimos 12 meses. O total de caídas foi de 25 e no 32% delas non se identificou o motivo na base de datos institucional. A maioría das caídas produciuse cando a persoa estaba soa (n=22) e cando estaba nun cuarto do instituto asistencial (n=21).

Realizouse unha análise da posible asociación entre ter unha caída previa e o risco de caídas. Porén, non se atopou unha asociación significativa ($p > 0,05$). Aínda así, cabe destacar que 11 dos 14 participantes que tiñan unha ou máis caídas previas estaban en risco de caer.

Risco de caídas

A partir dos resultados obtidos na presente investigación, determinouse que o risco de caída pode estar asociado a ter calquera nivel de dependencia en actividades básicas da vida diaria ($p = 0,002$, $V = 0,618$), realizar menos de 3.000 pasos ao día $p = 0,007$, $V = 0,618$), ter catro ou máis diagnósticos de saúde ($p = 0,006$, $V = 0,539$), utilizar produtos de apoio á mobilidade (p = 0,006, V = 0,532), ter calquera problema asociado a unha condición física (p = 0,018, V = 0,483) e utilizar andador (p = 0,03, V = 0,441).

En canto aos problemas identificados nas cinco dimensións do sistema descritivo EQ-5D-5L, atopouse unha asociación positiva e moderada cos problemas de mobilidade (p = 0,015, V = 0,585). Así, identificáronse asociacións fortes e negativas cos problemas no autocoidado (p = 0,002, V = -0,483) e unha asociación moderada cos problemas nas actividades cotiás (p = 0,018, V = -0,483). Non se determinou ningunha asociación entre o risco de caída e a dor e o malestar, ou a ansiedade ou a depresión.

Ademais, atopáronse asociacións entre o risco de caídas e o número de diagnósticos de saúde (F = 8, p = 0,007), o número de axudas á mobilidade utilizadas (F = 10, p = 0,003), a puntuación do Índice de Barthel (F = 16, p > 0,001), o Índice de gravidade da escala EQ-5D-5L (F = 5,3, p = 0,028) e o Índice EQ-5D-5L (F = 5,3, p = 0,028).

Calidade de vida relacionada coa saúde

En relación coa percepción subxectiva da calidade de vida, avaliada a través da EQ-5D-5L, a mostra representaba, como se indica na Táboa 4, unha EVA de aproximadamente 69 ± 15 (sendo superior a 50 puntos no 87,1% das persoas participantes), un Índice EQ-5D-5L de aproximadamente 0,68 ± 0,25, e un Índice de Gravidade de aproximadamente 22 ± 18.

Táboa 4: Datos obtidos na EuroQol-5D-5L sobre a calidade de vida subxectiva

	EVA	Índice EQ-5D-5L	Índice de Gravidade
Media	69	0,68	22
Desviación estándar	±15	±0,25	±18
Mínimo	40	0,03	0
Máximo	100	1	65

Asociacións dos parámetros da Xiaomi Mi Band 2

Utilizouse a proba t de Student e a proba U de Mann-Whitney para explorar a asociación entre os parámetros medidos pola Xiaomi Mi Band 2, que eran as variables independentes (pasos diarios, distancia diaria percorrida, sono profundo diario, sono superficial diario e tempo esperta/o nocturno diario), co feito de estar ou non en risco de caídas, a presenza ou non dalgún nivel de dependencia en AVD e a presenza ou non de deterioración cognitiva, que eran as variables dependentes (véxase Táboa 5)

Táboa 5: Asociacións entre os parámetros da Xiaomi Mi Band 2 xunto co nivel de independencia nas actividades básicas da vida diaria, o risco a caer e a deterioración cognitiva

Variables dependentes	Variables independentes					
	Pasos diarios	Distancia percorrida	Sono profundo	Sono lixeiro	Sono total	Total tempo esperta/o pola noite
Risco a caer	a**	a**	a	a	a	a*
Si	720 (±480)	446 (±61)	150 (±67)	271 (±93)	360 (±118)	56 (±44)
Non	3366 (±2139)	2,161 (±477)	174 (±20)	303 (±83)	421 (±85)	19 (±11)
Nivel de dependencias nas actividades básicas da vida diaria	b***	b**	b**	a	a	a
Si	696 (2593)	449 (1,651)	164 (180)	285 (385)	360 (533)	151 (17)
Non	4,509 (7213)	3,008 (4,817)	180 (149)	303 (252)	446 (141)	17 (41)
Deterioración cognitiva	a	a	b	b	b	a
Si	1,915 (±2,048)	1,232 (±1,381)	174 (264)	308 (278)	390 (209)	46 (±42)
Non	953 (±834)	569 (±507)	102 (186)	261 (385)	363 (533)	42 (±39)

[a] T de Student. Amósanse coa media (desviación estándar)
[b] U Mann-Whitney. Amósanse en mediana (rango)
P-valor >0.05*, >0.01**, >0.001***. O tamaño do efecto foi contrastado con G de Hedges.

Co risco de caídas, houbo fortes asociacións dos pasos diarios (p < 0,001, F = 27), a distancia diaria percorrida (p < 0,001, F=31), e unha débil asociación co tempo diario esperta/o pola noite (p = 0,013, F = 0,127).

As asociacións máis fortes coa dependencia nas actividades básicas da vida diaria foron cos pasos diarios (p < 0,001, g = -2,086, β = 0,99), a distancia diaria percorrida (p = 0,005, g = -2,666, β = 0,99) e o sono profundo diario (p = 0,005, g = -0,793, β = 0,54), Con todo, non se atoparon asociacións significativas coa deterioración cognitiva.

En relación coas dimensións descritivas do EQ-5D-5L, que eran as variables independentes, (véxase a Táboa 4), atopáronse fortes asociacións cos pasos diarios e a mobilidade (p = 0,001, g = -1,432, β = 0,97), o autocoidado (p > 0,001, g = 1 404, β = 0,97), as actividades cotiás (p < 0,001, g = 0,956, β = 0,76) e unha asociación moderada coa dor e o malestar (p = 0,008, g = 0,860, β = 0,68), así como asociacións similares atopáronse coa distancia diaria percorrida.

Concluíuse que cun maior número de pasos diarios e distancia diaria percorrida, identificáronse menos problemas de mobilidade e máis problemas de dor e malestar. Ademais, atopouse unha asociación moderada entre o sono superficial diario e a mobilidade ($p = 0{,}005$, $F = 3{,}78$), e coa dor e o malestar ($p = 0{,}003$, $g = 1{,}066$, $\beta = 0{,}84$). O sono total diario asociouse coa presenza de problemas nas actividades cotiás ($p = 0{,}042$, $g = 0{,}654$, $\beta = 0{,}53$) e unha baixa asociación coa dor e o malestar ($p = 0{,}02$, $g = -0{,}071$, $\beta = 0{,}07$). Non se atoparon asociacións entre o tempo diario profundo e o tempo diario esperta/o, coas dimensións do sistema descritivo da EQ-5D-5L.

Correlacións e asociacións cos pasos diarios

Os pasos diarios non tiveron relación coa idade, o sexo ou o IMC ($p > 0{,}05$), Con todo, tras a aplicación da proba de correlación de Pearson (distribución normal) e a correlación de Spearman (distribución anormal), identificáronse outras correlacións. Esta análise determinou que as correlacións significativas máis fortes e positivas cos pasos diarios foron coa puntuación do Índice de Barthel ($p < 0{,}001$, rho = 0,691), a puntuación do Índice EQ-5D-5L ($p < 0{,}001$, rho = 0,603) e a EVA da EQ-5D-5L ($p = 0{,}013$, rho = 0,377). As correlacións negativas máis fortes cos pasos diarios atopáronse no número de axudas vitais para a mobilidade utilizadas ($p < 0{,}001$, rho = -0,625), a puntuación do Índice de gravidade da EQ-5D-5L ($p < 0{,}001$, rho = -0,564, $\beta = 0{,}99$), o tempo total esperta/o pola noite ($p < 0{,}01$, rho = -0,506), o número de diagnósticos de saúde ($p < 0{,}01$, rho = -0,462), e o número de axudas de asistencia ($p < 0{,}05$, rho = -0,367). Non se atopou correlación coa idade ($p = 0{,}155$, rho = -0,262) nin coa puntuación da Escala de Tinetti ($p > 0{,}050$, rho = -0,063).

Regresión binaria do risco de caída

Verbo do risco de caída, realizouse un modelo de regresión binaria e obtívose un R^2 de Cox e Snell de 0,408 e un R^2 de Nagelkerke de 0,571, o que podería considerarse un modelo de bo axuste. Elimináronse do modelo as seguintes variables porque non tiñan un efecto preditivo sobre o risco de caídas: dar menos de 3.000 pasos ao día, presentar problemas asociados a algunha condición física, empregar axudas para a mobilidade, e percibir problemas nas áreas de autocoidado e mobilidade. Así, o modelo final suxería que unha persoa con risco de caída tiña 24 veces máis probabilidades de presentar calquera nivel de dependencia ($p = 0{,}016$, Odds Ratio = 24) e 11 veces máis probabilidades de ter catro ou máis diagnósticos de saúde ($p = 0{,}038$; Odds Ratio = 11).

Regresións binarias dos parámetros da Xiaomi Mi Band 2

Realizáronse regresións binarias (véxase a Táboa 6).

Táboa 6: Regresións binarias entre os parámetros da Xiaomi Mi Band 2 e o risco a caer, o nivel de independencia nas actividades básicas da vida diaria e o sistema descritivo da EuroQol-5D-5L.

Variable dependente	Variable independente	*Odds Ratio* 95% IC	R^2 de Cox and Snell	R^2 de Nagelkerke
Non risco a caer	Pasos diarios	1,004 (1,001-1,008) *	0,570	0,796
	Distancia diaria percorrida	1,006 (1,001-1,011) *	0,534	0,746
	Sono esperto durante a noite	0,913 (0,843-0,989) *	0,346	0,483
Independente nas actividades básicas da vida diaria	Pasos diarios	1,001 (1,000-1,003) *	0,375	0,571
	Distancia diaria percorrida	1,002 (1,000-1,004) *	0,388	0,591
	Sono esperto durante a noite	1,014 (0,995-1,033)	0,124	0,189
EQ-5D-5L Mobilidade-sen problemas	Pasos diarios	1,085 (0,926-1,272) **	0,411	0,587
	Distancia diaria percorrida	1,002 (1,001-1,004) **	0,420	0,599
	Sono lixeiro	1,024 (1,003-1,045) *	0,334	0,477
EQ-5D-5L Autocoidado-sen problemas	Pasos diarios	0,998 (0,996-1,000) *	0,424	0,576
	Distancia diaria percorrida	1,088 (0,811-1,460) *	0,453	0,615
EQ-5D-5L Actividades cotiás-sen problemas	Número de pasos	0,999 (0,998-1,000) *	0,261	0,349
	Distancia diaria percorrida	0,999 (0,997-1,000)	0,233	0,312
	Sono total	0,994 (0,985-1,003)	0,106	0,142
EQ-5D-5L Dor e malestar – sen problemas	Pasos diarios	0,999 (0,997-1,000)	0,321	0,428
	Distancia diaria percorrida	0,998 (0,995-1,000)	0,352	0,469
	Sono lixeiro	0,986 (0,974-0,999) *	0,303	0,404
	Sono total	0,993 (0,983-1,003)	0,225	0,300

IC = intervalo de confianza. Axustado por sexo, idade e índice masa corporal, *p<0,05; **p<0,01

En canto ás regresións binarias, un maior nivel de pasos diarios tivo unha asociación con máis probabilidades de: non ter risco de caídas ($p < 0,05$, Odds Ratio = 1,004, R^2 = 0,570-0,796); non percibir problemas na dimensión EQ-5D-5L Mobilidade ($p < 0,01$, Odds Ratio = 1,085, R^2 = 0,411-0, 587); non percibir problemas na dimensión EQ-5D-5L Actividades cotiás ($p < 0,05$, Odds Ratio = 0,999, R^2 = 0,261-0,349); non ter dependencia nas actividades básicas da vida diaria ($p < 0,05$, Odds Ratio = 0,913, R^2 = 0,375-0,571); e ter unha probabilidade menor de non percibir problemas na dimensión EQ-5D-5L Autocoidado ($p < 0,05$, Odds Ratio = 0,998, R^2 = 0,424-0,576).

En relación cos demais parámetros da Xiaomi Mi Band 2, observouse que unha maior distancia diaria percorrida se asociaba cunha maior probabilidade de non ter risco de caídas ($p < 0,05$, Odds Ratio = 1,006, R^2 = 0,534-0,746), unha maior probabilidade de non ter un nivel de dependencia nas actividades básicas da vida diaria ($p < 0,05$, Odds Ratio = 1,002, R^2 = 0,388-0,591), unha maior probabilidade de non percibir problemas na dimensión EQ-5D-5L Mobilidade ($p < 0,01$, Odds Ratio = 1,002, R^2 = 0,420-0,599) e unha menor probabilidade de non percibir problemas na dimensión EQ-5D-5L Autocoidado ($p < 0,05$, Odds Ratio = 0,998, R^2 = 0,453-0,615). O tempo total esperta/o pola noite asociouse cunha probabilidade menor de non ter risco de caídas ($p < 0,05$, Odds Ratio = 0,913, R^2 = 0,346-0,483). Ademais, o sono lixeiro diario asociouse con non percibir problemas na dimensión EQ-5D-5L Mobilidade ($p < 0,05$, Odds Ratio = 1,024, R^2 = 0,334-0,477) e unha probabilidade menor de non percibir problemas na dimensión EQ-5D-5L Dor e malestar ($p < 0,05$, Odds Ratio = 0,986, R^2 = 0,303-0,404).

Modelo xeneralizado de pasos diarios

Aplicouse un modelo xeneralizado cunha distribución de función de ligazón Gamma e Logaritmo. A variable dependente foi o número de pasos diarios coas correlacións e asociacións máis fortes que se atoparon anteriormente.

Os resultados do modelo xeneralizado preséntanse na Táboa 6. Moitas das variables con asociación ou correlación significativa foron eliminadas por non seren predictores significativos. Finalmente, obtívose que os pasos diarios tiñan unha asociación negativa co risco de caídas ($p < 0,001$, Odds Ratio = 0,312) e máis cando unha persoa tiña algún nivel de dependencia nas actividades básicas da vida diaria ($p = 0,27$, Odds Ratio = 0,567). Isto significa que unha persoa tiña un risco 0,312 veces maior de caer ou unha dependencia 0,567 veces maior nas actividades básicas da vida diaria cando camiñaba menos pasos ao día, o que significa que cantos máis pasos se dean ao día, máis probable é non correr o risco de caer ou presentar dependencia. Concretamente, unha persoa ten aproximadamente o dobre de probabilidades de non correr o risco de caer ou presentar dependencia se ten un nivel adecuado de pasos diarios. Así, os datos amosan que as persoas con risco de caída deron menos pasos ao día (entre 146 e 1.920) en comparación coas persoas sen risco de caída, que deron máis pasos ao día (entre 1.188 e 7.942). Noutras palabras, o número medio de pasos dados polas persoas con risco de caída foi menor (937 ± 738), mentres que os dados polas persoas sen risco de caída foi maior (3.755 ± 2.527). Así mesmo, as persoas en situación de dependencia deron menos pasos ao día (entre 146 e 2.739) en comparación coas persoas independentes, que deron máis pasos ao día (entre 729 e 7.942). Así mesmo, obsérvase que a media de pasos ao día das persoas en situación de dependencia foi menor (937 ± 738) mentres que a media de pasos ao día das persoas independentes foi maior (3.755 ± 2.527).

Capítulo IV: Discusión

IV.1. Discusión dos principais resultados obtidos

O obxectivo principal que se definiu na tese de doutoramento foi dar a coñecer unha solución tecnolóxica accesible que axude a previr ou reducir o risco a caer, e así promover que as persoas maiores teñan un desempeño ocupacional satisfactorio e saudable. Con respecto a isto, a tese de doutoramento no artigo 1 (*III.1. Estudo I. Tecnoloxías para a medicina participativa e a promoción da saúde na poboación maior)* achega o deseño do proxecto GeriaTIC, no cal se desenvolveu unha aplicación web para o rexistro das ocupacións das persoas maiores e o asesoramento ocupacional. Así mesmo, no artigo 2 (*III.2. Estudo II. Terapia ocupacional e o uso da tecnoloxía na prevención de caídas en persoas maiores: revisión de alcance*) tamén se dan a coñecer as alternativas tecnolóxicas que se están a empregar nas intervencións de TO para abordar este fenómeno e, ademais, no artigo 3 (*III.3. Estudo III. Análise do risco a caer e a actividade diaria de persoas maiores en residencias en España usando a Xiaomi Mi Band 2*), os resultados acadados amosan que os dispositivos poñibles ou *wearables,* especialmente a *Xiaomi Mi Band 2*, pode ser unha ferramenta de avaliación da vida diaria das persoas maiores.

O desenvolvemento do Estudo I representa unha importante innovación no escenario actual dos sistemas de seguimento das persoas maiores baseados no paradigma da historia clínica persoal. A integración das características deste paradigma nunha única plataforma que permita, de forma autónoma e libre, compartir e xestionar a información sanitaria entre as persoas, profesionais da saúde e familiares ou outras persoas da súa contorna próxima, é unha formulación innovadora nos países europeos. Asemade, tamén integra un programa de intervención multifactorial, o que se erixe como o tipo de intervención considerada efectiva para a abordaxe das caídas de acordo con Close *et al.* (1999).

O Estudo II representa a primeira revisión de alcance sobre as intervencións de TO para abordar as caídas da poboación maior utilizando a tecnoloxía. Os obxectivos definidos para esta revisión centráronse en explorar a literatura sobre o tema para determinar o tipo de estudos realizados, onde se publicaron habitualmente tales estudos, e os enfoques e estratexias empregados desde a TO, a través de dispositivos tecnolóxicos, para reducir o risco de caídas.

Os resultados mostran que se trata dunha área emerxente, que comezou a investigarse no ano 2012, coa revisión desenvolta por Chase *et al.* (2012). A devandita revisión enfocouse na modificación do fogar e unicamente se mencionou a teleasistencia como unha posible estratexia dos/as terapeutas ocupacionais, pero estes/as non desenvolveron especificamente ese estudo. Tal e como se comentaba no apartado I.3. Abordaxe das caídas, proxectos previos focalizáranse na abordaxe das caídas co uso da tecnoloxía. Por exemplo, o proxecto iStoppFalls (Marston *et al.,* 2015) centrouse no uso de videoxogos para reducir as caídas da poboación maior; este proxecto levouse a cabo de 2011 a 2014 para potenciar a realización de actividade física por parte de persoas maiores de 65 anos que viven na comunidade mediante a participación en tres videoxogos creados especificamente para reducir as caídas.

Na presente revisión de alcance amósase unha tendencia para realizar estudos cun enfoque cualitativo (Glännfjord *et al.,* 2017; Lo Bianco *et al.,* 2016) e estudos de métodos mixtos (Hamm *et al.,* 2017, 2019; Lemmens, R; Gielen, C; Spooren, 2017), o que reforza a idea de que é importante comprender as percepcións e experiencias sobre o uso da tecnoloxía das propias persoas maiores, ou doutras persoas da súa contorna próxima (como terapeutas ocupacionais e outras/os profesionais da saúde, ou persoas coidadoras). Este tipo de investigación axúdanos a entender a aceptación ou non da tecnoloxía e a determinar como mellorala ou adaptala para que sexa útil no día a día das persoas maiores (Özsungur, 2019).

No que ten que ver co lugar de publicación, realizáronse un número similar de estudos entre Estados Unidos (Arthanat *et al.,* 2019; Charness, 2014; Chase *et al.,* 2012; Horowitz, Nochajski, & Schweitzer, 2013) e países de Europa (Glännfjord *et al.,* 2017; Hamm *et al.,* 2017, 2019; Lemmens, R; Gielen, C; Spooren, 2017; Money *et al.,* 2019; Stewart & McKinstry, 2012), a pesar de que Europa é unha das rexións máis afectadas polo envellecemento progresivo da poboación (OMS, 2011a), e tendo en conta que os proxectos europeos anteriores, como *Prevent IT*, *Farseeing* e *iStoppFalls*, que son un antecedente esencial para a prevención de caídas a través do uso da tecnoloxía, desenvolvéronse en Europa (Boulton et al., 2016, 2019; Marston et al., 2015). Australia é unha localización onde existen varias experiencias de abordaxe das caídas (Clemson *et al.,* 2012; Gibbs *et al.,* 2019; Merom *et al.,* 2016; Roberts et al., 2003; Robins et al., 2016; Zhang et al., 2019), pero nas bases de datos utilizadas na busca unicamente se localizou un estudo (Lo Bianco *et al.,* 2016).

En comparación con outras revisións sobre caídas e TO, os resultados da presente revisión de alcance son de menor calidade de investigación, xa que non foi posible atopar ningún ensaio controlado que demostrase a eficacia das intervencións desenvolvidas xunto á tecnoloxía. En cambio, realizáronse algúns ensaios controlados no ámbito das caídas e a TO, por exemplo, o de Di Monaco *et al.* (2008).

Só un dos tipos de software desenvolvidos, e que formaran parte dos resultados seleccionados da revisión, foi a dixitalización da ferramenta *Obstacle* (Lemmens, R; Gielen, C; Spooren, 2017), a cal se probou con persoas maiores, terapeutas ocupacionais e coidadoras/es informais. O obxectivo era que fose accesible para todas as persoas, o cal é un factor esencial para ter en conta no desenvolvemento de software, segundo o modelo de desenvolvemento de software accesible (Sá *et al.,* 2019), a filosofía de deseño universal, e a perspectiva inclusiva da TO (Oxford Institute of Population Ageing, 2018), xa que todo isto contribúe a romper a fenda dixital, particularmente entre a poboación maior.

En canto ao tipo de intervención utilizada para abordar as caídas desde a TO, cabe salientar que só se utilizaron intervencións dun só compoñente (Elliott & Leland, 2018) a pesar de que a evidencia previa suxire que os programas multifactoriais contribúen en maior medida a previr e reducir as caídas debido á súa complexidade (Morello *et al.,* 2019). Ningún dos estudos analizados incluíu un equipo interprofesional, a pesar da súa importancia. A eficacia dos programas multifactoriais, como se mencionou previamente, tamén se debe ao uso dun equipo interprofesional para a prevención e o tratamento das caídas.

Con respecto aos programas multifactoriais (Morello *et al.,* 2019), estes incluían o exercicio, como se fixo en dous estudos incluídos nesta revisión (Ben Haj Khaled *et al.,* 2020; Glännfjord *et al.,* 2017); a avaliación individualizada e exhaustiva do risco de caídas sobre a contorna da persoa maior, como se fixo nalgúns estudos mencionados no artigo 1 (Hamm *et al.,* 2017, 2019; Horowitz, Nochajski, Schweitzer *et al.,* 2013; Lemmens, R; Gielen, C; Spooren, 2017; Lo Bianco *et al.,* 2016) e educación sobre a prevención de caídas, como se fixo en dous estudos (Horowitz, Nochajski, Schweitzer *et al.,* 2013; Money *et al.,* 2019). Ademais, as intervencións desde a TO deberían engadir visitas domiciliarias (Brandis & Tuite, 2001), que pode ser un aspecto esencial para incluír, especialmente naqueles casos de modificación do fogar e no uso da tecnoloxía de asistencia.

Os estudos que integraron a filosofía de *ageing in place* centráronse na tecnoloxía de asistencia e as modificacións do fogar porque estes factores son amplamente recoñecidos como as intervencións principais e preferidas durante o envellecemento (Fernández-Carro, 2016; Wiles et al., 2012). Así, un aspecto importante e necesario é comprender que ter en conta as necesidades das persoas maiores pode contribuír a mellorar a súa calidade de vida, que se ve afectada tras unha caída.

Unha revisión sistemática anterior explorou a rendibilidade de varias intervencións de TO para persoas maiores e concluíu que son útiles e rendibles en comparación coa atención estándar ou outras terapias (Nagayama et al., 2016). Deste xeito, o impacto socioeconómico é unha das consecuencias das caídas (Balzer *et al.,* 2012). No entanto, os resultados non se centraron en aspectos relacionados co impacto socioeconómico.

Por tanto, os achados desta revisión de alcance reforzan a idea de que as modificacións no fogar, a tecnoloxía de asistencia e as intervencións educativas poden abordar os factores extrínsecos, en particular, os factores ambientais, mentres que o exercicio pode abordar os factores intrínsecos. Isto concorda con estudos anteriores sobre o uso de intervencións de TO para abordar o risco de caídas (Cumming et al., 1999; Lord et al., 2006; Somerville et al., 2016; Walker & Howland, 1991). Aínda que, como se mencionou anteriormente, algúns exemplos de tecnoloxía de asistencia utilizada para previr as caídas na poboación maior inclúen a vídeovixilancia, a vixilancia da saúde, os sensores electrónicos e os detectores de caídas (Miskelly, 2001), estes non se incluíron nos estudos mencionados nesta revisión.

O Estudo III enfocouse en examinar os parámetros da *Xiaomi Mi Band 2* e a súa relación coa calidade de vida e o estado de saúde, focalizando a análise na actividade física e o risco de caídas. Os principais resultados obtidos foron que un maior número de pasos e distancia percorrida podería supoñer unha menor probabilidade de presentar risco de caída, dependencia nas actividades da vida diaria ou percepción de problemas de mobilidade. Deste xeito, tal e como conclúe o estudo de Paterson & Warburton (2010), non hai acordo sobre que dose de actividade física se debe realizar para manter a independencia funcional dunha persoa maior. Sábese que con niveis moderados de actividade física, pode haber resultados significativos (Paterson & Warburton, 2010). Así mesmo, está ben documentada desde hai décadas a relación entre o mantemento da actividade física e a realización de actividade física regular, cos beneficios para a saúde, especialmente na redución da taxa de caídas (Sherrington *et al.,* 2019).

O número de pasos dados polas/os participantes que non perciben problemas de mobilidade, non teñen risco de caídas e son independentes nas actividades da vida diaria básicas, foron entre 2.503 pasos medianos nun rango de 7.256, unha media de 3.366 pasos ± 2.139 e, unha media de 4.509 nun rango de 7.213, respectivamente. É dicir, considerando estes tres aspectos, o número de pasos diarios oscila entre 2.500 e 6.000 pasos aproximadamente. Do mesmo xeito, obtivéronse datos similares no estudo de O'Brien *et al.* (2015), en que os pasos intermedios da poboación maior foron de 2.500 a 4.000. Así, segundo Tudor-Locke *et al.* (2011), este rango axústase a un perfil sedentario. Estes autores suxiren que menos de 6.000 pasos diarios non poderían proporcionar beneficios para a saúde. Ademais, suxiren que os niveis de actividade física deberían aumentar, aínda que hai que ter en conta que a idade media da mostra era de 84 ± 8,71 anos, cun 87,1% de participantes que dan menos de 3.000 pasos ao día. Por tanto, non está claro se este nivel de actividade física pode afectar significativamente á súa saúde.

Os pasos diarios son un factor modificable intrinsecamente relacionado coa avaliación obxectiva da actividade física diaria. Teñen un forte impacto na saúde en calquera poboación, pero especialmente nas persoas maiores. Afecta ao seu nivel de independencia e calidade de vida, tendo en conta as repercusións das caídas. Este estudo suxire que os dispositivos *wearables,* como a *Xiaomi Mi Band* 2, poden utilizarse para realizar avaliacións adecuadas, que poden axudar a identificar a presenza dun maior risco de caídas para reducir o impacto negativo destas (Ambrose et al., 2013).

O 45,2% da mostra tiña caídas previas, sabendo que a súa incidencia normal nas residencias de persoas maiores é do 50% (OMS, 2004). Por todo isto, a pesar da situación de pandemia, as caídas seguen cobrando grande importancia (De La Cámara *et al.,* 2020), o que as converte nun foco de atención. Neste caso, as/os profesionais da saúde e as/os coidadoras/es desempeñaron un papel fundamental para mitigar a asunción de riscos innecesarios (Haines et al., 2015). Neste Estudo III, analizouse tamén a asociación entre ter unha caída previa e o risco de caída, aínda que non se atopou ningunha asociación significativa. Estudos anteriores indicaron que as persoas maiores que experimentan caídas teñen unha alta prevalencia de factores de risco de caídas e corren o risco de sufrir unha deterioración funcional (Russell et al., 2006). Como xa se mencionou, púidose observar un menor risco de caídas a maior nivel de actividade física.

No relativo ao sono, neste estudo observouse que o tempo total esperta/o pola noite se pode asociar co risco de caídas ($p = 0,013$, $F = 0,127$). Aínda que os datos non están apoiados por asociacións fortes e sabendo que é necesario considerar a calidade do sono medida polo sono profundo, o sono superficial e o sono total, mostra un aspecto importante do uso de dispositivos *wearables*. Estes dispositivos fan un seguimento continuo da persoa, o que proporciona o tempo aproximado que a persoa estivo esperta pola noite e, por tanto, poden axudar a comprender as súas necesidades con respecto ao equilibrio ocupacional.

Deste xeito, Štefan *et al.* (2018) informaron de que as persoas maiores cunha curta duración do sono teñen unha menor propensión a cumprir as directrices de actividade física. Pola contra, aquelas persoas que informan dunha longa duración do sono e unha boa calidade do sono teñen máis probabilidades de cumprir coas directrices de actividade física. No presente estudo, as/os participantes que percibían problemas de mobilidade amosan unha maior propensión a ter un sono máis superficial a diario. Pola contra, as persoas con problemas percibidos de dor e incomodidade teñen un maior risco de presentar menos sono superficial diario. Noutras palabras, atopouse que as persoas con dor e malestar subxectivos poden tomar menos sono superficial. Con todo, habería que comparalo co sono profundo e así examinar a calidade do sono, pero neste caso non se atoparon asociacións significativas para concluír. Do mesmo xeito, non se atoparon relacións significativas coa deterioración cognitiva e os problemas percibidos nas actividades cotiás, nin cos parámetros totais do sono e o sono profundo.

A literatura existente apoia unha relación entre a curta duración do sono e as lesións por caídas (Sherrington *et al.,* 2008). E tamén, que o mantemento das rutinas diarias se asocia cunha menor taxa de insomnio na poboación maior (Zisberg et al., 2010). No presente estudo, o 54,83% das/os participantes dorme menos de 420-480 minutos, que é o rango adecuado de sono por día (Fundación do Sono, 2021), mentres que as/os participantes con risco de caída dormen 360 ±118 minutos por día en comparación coas persoas que non teñen risco de caída, que dormen 421 ± 85 minutos por día. Isto significa que se observou que as persoas que non teñen risco de caídas dormen máis, e os niveis de sono están dentro do rango apropiado, aínda que non foi posible concluír unha relación significativa.

En canto ao risco de caída, atopamos que unha persoa con risco de caída ten 24 veces máis probabilidades de presentar algún nivel de dependencia e 11 veces máis probabilidades de ter catro ou máis diagnósticos de saúde, seguindo os factores de risco recollidos pola OMS, que especifican diferentes condicións médicas, problemas de mobilidade e marcha e comportamento sedentario, entre outros (OMS, 2004). Así, o risco de caídas pode estar relacionado coa dependencia e a comorbilidade, Non se estableceu a asociación entre o uso de axudas á mobilidade, que pode afectar ao número de pasos diarios. Tampouco se puido determinar se estas axudas poden ser un facilitador ou unha barreira na vida diaria da poboación maior.

IV.2. Limitacións

As principais limitacións da presente tese de doutoramento en relación coa revisión de alcance son que só se incluíron artigos en español, portugués e inglés, e o feito de seren realizadas as buscas por unha mesma persoa pode provocar que algunha información de forma inconsciente fose excluída. Porén, na revisión foron escasos os filtros utilizados para non limitar o número de resultados.

En relación co estudo descritivo, o tamaño da mostra foi limitado, polo que este sería un aspecto de mellora cara ao futuro e tamén o feito de ter unha mostra heteroxénea. Así mesmo, deberíanse incluír aspectos como o medo a caer, a medicación, a nutrición, ou a adaptación da contorna, para ampliar a análise dos datos.

IV.3. Futuras liñas de investigación

Derivado do artigo 1, preténdese que se cren protocolos específicos de intervención en tres áreas de especial preocupación para as persoas maiores: a incontinencia urinaria, o risco de caídas e o insomnio ou outros trastornos do sono. Tamén se propón a realización dun estudo que, ao implicar e apoderar a persoa maior no control da súa saúde, permita unha maior autonomía nesta etapa vital, diminuíndo o apoio externo continuado. Así mesmo, considérase relevante levar a cabo no futuro unha adaptación da aplicación web e as súas interfaces para que poidan ser accesibles e útiles para todas as persoas maiores, independentemente de que presenten algunha limitación a nivel cognitivo, sensorial e/ou físico. Finalmente, sería tamén importante desenvolver a integración da aplicación web cos dispositivos poñibles *(wearables)* para verificar, en tempo real, a execución das actividades propostas como parte da intervención.

Como resultado da revisión recollida no artigo 2, suxírese que o persoal investigador e terapeutas ocupacionais deste campo realicen máis estudos que inclúan a última tecnoloxía no campo das caídas, co fin de proporcionar máis evidencia científica. Así, deberíanse integrar intervencións interprofesionais e multifactoriais.

Ademais, en relación co artigo 3, sería importante realizar un estudo de casos e controis cun tamaño de mostra adecuado para determinar se ter risco de caídas inflúe no número de pasos diarios dados, xa que este estudo suxire que as persoas que non teñen risco de caídas poderían dar máis pasos ao día. Ademais, outros estudos deberían incluír outras variables non analizadas neste estudo descritivo, como o medo ás caídas, a medicación, a nutrición ou a adaptación da contorna, para profundar en como inflúen no risco de caídas.

IV.4.Implicacións clínicas

A través desta tese de doutoramento amósase a importancia de buscar solucións útiles que faciliten o día a día das persoas maiores e dos equipos profesionais que traballan directamente con elas. Por esa razón, a tese está enfocada no uso da tecnoloxía, a cal pode facilitar o día a día da poboación maior e tamén a práctica profesional do persoal socio-sanitario.

Ademais, preténdese espertar o interese de futuras investigacións a que sigan na liña sobre a abordaxe das caídas co uso da tecnoloxía desde a TO, xa que posiblemente existan máis experiencias ao respecto, pero non están, polo de agora, publicadas ou totalmente accesibles.

Por último, faise fincapé no uso de dispositivos *wearables,* como por exemplo a *Xiaomi Mi Band 2*, que poden achegar información sobre o estado de saúde da persoa maior sen necesidade de dedicar tempo presencial para a súa avaliación. Esta é unha opción non invasiva que pode axudar a comprender as necesidades das persoas maiores en tempo real en relación coa súa participación ocupacional e o equilibro entre as diferentes ocupacións desempeñadas pola persoa. Da mesma maneira, facilita á propia persoa maior ser consciente do seu estado de saúde, do seu nivel de actividade física e da súa calidade do sono dunha forma inmediata e obxectiva.

Chapter V: Conclusions

The main conclusion is that wearable devices can be an affordable, convenient and intuitive alternative to include in the assessment and intervention of occupational therapists, whitin interdisciplinary and multifactorial programs, to promote quality of life, occupational participation and, active ageing in older people.

Falls prevention in older adults using technology by occupational therapists is an emergin area because the existing literature is sparse.

Studies in the existing literature were mainly conducted in the United States and Europe and published in occupational therapy and computer science journals. The target population is those over 50 years of age. The risk factors that were evaluated and considered most frequently are extrinsic factors, especially environmental ones. Occupational therapy interventions using technology to address falls in older adults were single-component methods, including home modifications, assistive technology, educational intervention, and exercise. The technology used in the studies can be categorized as software developments, telehealth, multimedia material, and commercial technology devices.

The main findings obtained were that a greater number of steps and distance could be related to a lower probability of presenting fall risk, dependence on basic daily activities, or perception of mobility problems. The risk of falls may be related to dependence and comorbidity; however, we cannot determine whether mobility aids can be a facilitator or a hindrance in the daily lives of older adults.

According to the results, cognitive impairment has no strong associations with any of the selected parameters of the Xiaomi Mi Band 2 (steps, distance, deep sleep, shallow sleep, total sleep, and time awake at night).

In terms of sleep, the results suggest that people at risk of falling tend to be awake longer at night, independent people have more deep sleep, people who identify problems with usual activities have less total sleep time, and finally, people who identify pain or discomfort have less light sleep and total sleep.

Finally, wearable devices continuously monitor the person, which may help to understand their needs. The importance of focusing on daily steps, intrinsically related to the objective assessment of daily physical activity, is that it is a modifiable factor that impacts different aspects of health, quality of life and risk of falls.

Capítulo VI: Referencias

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Apéndices

Estudo 1

Study Protocol Clinical Trial

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Technologies for participatory medicine and health promotion in the elderly population

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Abstract

Introduction: The progressive aging of the population is a socio-demographic phenomenon experienced by most countries in the world in recent decades, especially in Japan and in many European Union countries. During this process, so-called "geriatric syndromes" frequently occur. The focus of this study is the quality of life of the elderly in relation to these 3 factors: risk of falls, urinary incontinence, and insomnia.

Objective: The main purpose is to determine the impact of a multifactorial intervention program implemented with institutionalized elderly people. The program is focused on the treatment of the aforementioned factors.

Methods and Analysis: The study will be carried out with elderly people living in three residences for the elderly in A Coruña Province (Galicia, Spain).It is a prospective and longitudinal study, with a temporary series design of a "quasi-experimental" type that evaluates the effect of an intervention in 1 given population by doing assessments pre- and post-intervention, but there is no comparison with a control group.

The intervention will be based on a multifactorial program, including the following phases: the use of wearable devices (wearable fitness trackers to register physical activity and sleep), the use of an App on a Tablet to record the participants' occupations and activities, counseling about performance in activities of daily living, the implementation of a physical activity program, and the treatment of the pelvic floor (according to each research line). The Quality of Life (QoL) will be assessed before and after the intervention, with the use of the questionnaire EuroQol-5D-5L. Data analysis will be applied with all registered variables through a quantitative perspective.

Ethics and Dissemination: The protocol has been approved by the host institution's ethics committee (Research Ethics Committee of Galicia) under the number 2017/106. Results will be disseminated via peer-reviewed journal articles and conferences. This clinical trial is registered at ClinicalTrials.gov identifier: NCT03504813.

Abbreviations: ADL = activities of daily living, CCI = Charlson Comorbidity Index, EQ VAS = EQ Visual Analog Scale, EU = European Union, FES-I = Falls Efficacy Scale International, ICF = International Classification Functioning, ICIQ-SF = International Consultation on Incontinence Questionnaire (Short Form), MMSE = Mini-m State Examination, PSQA = Pittsburgh Sleep Quality Assessment, QoL = Quality of Life, SPIRIT = Standard Protocol Items for Randomized Trials, UI = urinary incontinence.

Keywords: elderly, insomnia, quality of life, risk of falls, urinary incontinence, wearables

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Trial registration: ClinicalTrials.gov identifier: NCT03504813

Code of ethical committee: 2017/106

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The authors declare no conflicts of interest.

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1. Introduction

1.1. Background and rationale

The progressive aging of the population is a demographic phenomenon in most countries of the world in recent decades, especially Japan and the countries of the European Union (EU).[1] Today, people aged 60 years or older represent 23.8% of the total Spanish population, and those aged 65 years or older represent 18.4%. Thus, Galicia is among the greatest aging regions in Spain, both in absolute and relative numbers.[2]

Although aging is not a pathology or disease, it is known that old age is the life stage where the greatest risks exist for the appearance of pathology and/or chronic diseases. The World Health Organization (WHO) plans to detect and treat these diseases in time, in order to minimize their consequences, through a comprehensive primary care system.[3]

Characteristic of aging are the "geriatric syndromes," and among them, the most frequent are:

(i) Urinary incontinence: the involuntary loss of urine through the urethra, objectively demonstrable and constituting for the person who suffers it a social and hygienic problem.[4]

(ii) Falls: involuntary events that cause people to lose balance and find themselves on the ground or other firm surfaces.[5] The factor of falls can be intrinsic (related to the person) or extrinsic (derived from the activity or environment of the individual).

(iii) Insomnia: a condition characterized by an unsatisfactory amount or quality of sleep which persists for a considerable period. This disorder includes difficulties for the falling and/or staying asleep and early awakening in the final phase of sleep.[6]

These geriatric syndromes constitute the 3 research lines of the present project. Related to these syndromes are a wide range of possibilities for primary, secondary, and tertiary prevention, the ability to direct efforts to avoid or reduce the appearance of these disorders, improve early diagnosis and slow down its evolution, or reduce its complications and side effects.[7–9]

Relating the mentioned geriatric syndromes with the concept of "Internet of things" and the possibilities of new technologies, this project intends to integrate different sensor devices (or wearables) able to monitor users in a non-invasive way and feed the system with the collected data in order to offer specific interventions for different user profiles.[10]

Currently there are numerous commercial solutions for monitoring health parameters of users through sensor devices capable of transmitting data to other devices, such as a mobile phone or a computer. Among these solutions are quantifying bracelets for physical exercise and/or sleep, scales, glucometers, tensiometers, heart rate monitors, ans so on.[11]. However, the 3 research lines that we are considering in this study are neither adequately nor completely covered today by commercial devices. Therefore, a significant part of the research work consists of being able to define, based on the requirements indicated by the participating health professionals, a set of "models" of sensors capable of measuring the pertinent parameters, which is not possible by using only commercial solutions. On the other hand, the personal and non-transferable use that is going to be made of the sensors by the users forces the costs of the same to be moderate, which limits the range of devices that can be included. What matters, in short, are reliable and affordable sensor devices for the end user, without neglecting technology and efficiency.[10]

Participatory Medicine is a model of health care that highlights the active role of the patient, based on the collaboration and empowerment of the patient. Moreover, digital revolution allows for empowerment of patients, which helps them in their own treatment and care. Current studies are demonstrating that this type of responsibility from the patient significantly improves treatment times, reduces the time and amount of drug use and, importantly, causes people to increase their level of well-being by feeling they are part of the process of healthcare.[12]

The present research focuses on the study of the use of information and communication technologies by elderly people to promote their health. The objective of the project is to investigate and develop a technological solution that offers services oriented toward evaluation and intervention with the elderly in the 3 research lines: increasing urinary continence, detection, and prevention of falls and sleep control. However, the project will be designed and developed on a web-based-platform (transversal) to include other areas related to the elderly's health.

1.2. Objectives

The main purpose is to determine the impact on quality of life of a multifactorial intervention program implemented with institutionalized elderly people with urinary incontinence, sleep disorders, and/or risk of falls.

The specific objectives are:

(i) To facilitate the reduction of the symptoms and signs of these geriatric syndromes (urinary incontinence, sleep disorders, and risk of falls).

(ii) To analyze the changes produced after the intervention in the occupations of the elderly.

(iii) To promote the use of technology devices in the daily lives of the elderly, especially for the empowerment and management of their health.

(iv) To increase the responsibility and active participation of the elderly in their health and aging process.

1.3. Study design

The study will use a temporary series design of a "quasi-experimental" type, aimed at assessing the effect of an intervention on a given population by performing pre- and post-intervention measurements, but without existing comparison with a control group. The design is longitudinal and prospective.

This study protocol follows the Standard Protocol Items for Randomized Trials (SPIRIT).[13]

2. Methods: participants, interventions, and outcomes

2.1. Study setting

The study will be carried out in 3 residences for the elderly in 3 different cities of the A Coruña region (Spain). The project has duration of 36 months, from March 2017 to December 2019.

2.2. Eligibility criteria

There will be a convenience sample. Participants will be people older than 65 years old, living in 1 of the 3 residences involved in the study, who meet the inclusion criteria.

The general inclusion criteria is people with 65 years of age or older.

Specific criteria for each research line:

- Urinary incontinence:
  To have stress, urgency or mixed urinary incontinence
  To be a woman
- Insomnia:
  Diagnosis of insomnia and/or hypersomnia.
- Risk of falls:
  To have a previous history of falls in the last 6–12 months.
  To present risk of falling and/or fear of falling.
  To have independence in locomotion.

The general exclusion criteria are:

(i) Showing cognitive deterioration from moderate to very severe (Mini-Examination Cognitive <20 points).

(ii) Having severe, acute complications in health that prevent assiduity in attending interventions.

(iii) Diagnosis of conditions and/or pathologies in which physical activity is contraindicated (mainly cardiorespiratory diseases).

(iv) Being in the final stage of a terminal illness.
(v) Bing in a situation of request for transfer to another center.
(vi) Having a temporary stay in elderly residence.
(vii) Having a situation of legal incapacity.

Specifically, for the research line on urinary incontinence, several specific exclusion criteria have been established:

(i) Having functional urinary incontinence because that type is related to cognitive deterioration, urinary infection, polypharmacy, psychological problems, endocrinopathy, mobility restriction, and fecal incontinence.[14]
(ii) Having undergone surgery in the pelvic floor area.
(iii) Uterine prolapse, cystocele and/or rectocele (levels 3–4).
(iv) No control of the pelvic floor.

2.3. Interventions

Intervention will consist of a multifactorial program with the follow stages: the use of wearable devices (wearable fitness tracker to register physical activity and sleep), the use of an App on a Tablet to record the participants' occupations and activities, counseling about performance in the activities of daily living, the implementation of a physical activity program, and the treatment of the pelvic floor (according to each research line). The process of intervention is showed in Figure 1.

From the beginning, participants will receive wearable fitness trackers to register data about physical activity and quality of sleep. The wearable device offers the possibility of programming alarms or notifications.

Moreover, participants will record information themselves, daily or monthly (according to type of data), about different aspects of their occupational performance. That register will be done through the App OcupaSenior-TIC. The Tablet with a specific App and the wearable device will be used transversally throughout the whole project.

The first sessions of intervention will be focused on training with the technological devices (Tablet and wearable). The number of sessions and the duration of training will depend on the needs of participants.

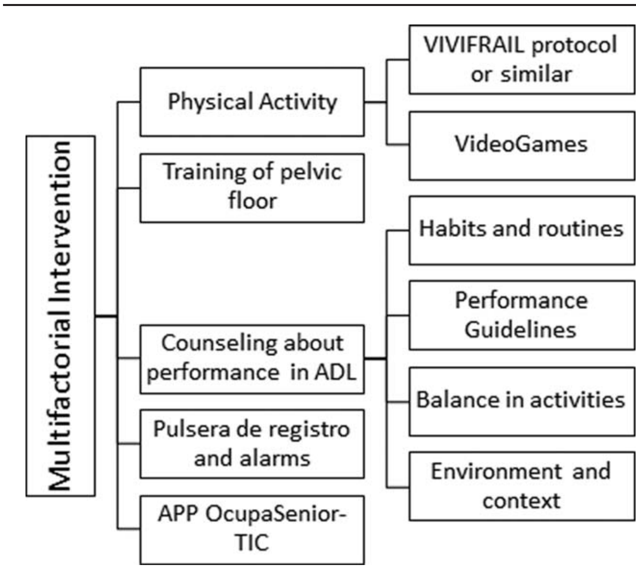


Figure 1. Scheme of Multifactorial Intervention Program.

Once the different technological devices are integrated, the development of activities in the multifactorial intervention program will start: counseling about occupational performance, a physical activity program and relaxation or training of the pelvic floor, according to the research line in which participants are enrolled:

(1) Physical activity programs: To implement this line, the protocol of the VIVIFRAIL Project will be used as a reference. That protocol has different physical exercises, divided into itineraries, in order to adapt it to a person's capability.[15] Several sessions of this research line will employ the use of videogames so that the elderly can explore new forms of physical activity and thus establish contact and expertise with new technologies. It is estimated that 3 sessions per week over 2 months are needed for each person to continue doing physical activity independently and with autonomy.
(2) The relaxation training will take place with those participants who are included in the research lines of insomnia and risk of falls. It is estimated that 2 sessions per week for 1 month are needed.
(3) The training of the pelvic floor will apply to participants enrolled in the research line dealing with urinary incontinence during the 6 months of intervention, with a frequency of 2 sessions per week.
(4) Counseling about occupational performance: After the physical activity and relaxation programs, the counseling will start. With each participant, routines and daily activities will be planned that will be adequate according to different recommendations about urinary incontinence, insomnia, and risk of falls. Different performance guidelines will be established in order to establish a good balance between activities. The guidelines can include the recommendations about adjustments to the environment. It is estimated that three sessions per week for 2 months are needed to incorporate advice and routines into the daily lives of participants.

All sessions will carry on in groups of 6 people, and their duration will be 45 minutes each.

2.4. Software

An App for Tablet with Android System will be designed and created, and it is called App OcupaSenior-TIC. This App will be a health manager, promoting participative health, in which participants will record, daily and monthly, their different occupations and/or relevant information concerning urinary incontinence, insomnia, and falls. This App will be linked with ClepIO, which is an online health application, to manage the clinical history and personal record of each participant's own health, as well as to monitor the pharmacological treatment.

2.5. Participant timeline

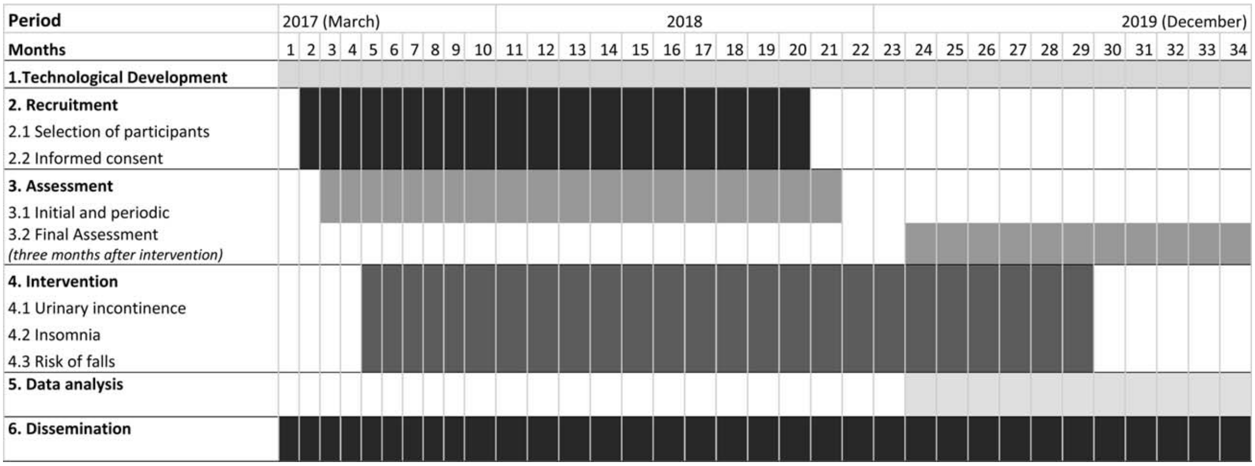
The first contact with possible participants started in April 2017. They were given the information letter and the informed consent at the same time. The process of assessment is periodic, starting in May 2017 and finishing in November 2018.

The intervention with each group of participants starts in July 2018, with a duration of 24 months. The final assessment will start in February 2019, 3 months after the end of interventions.

The complete timeline on development of the project is shown in Table 1.

Table 1

Timeline of research project.



2.6. Sample size

In order to get 95% safety, a power of 80%, a mean difference of 0.05, and a correlation coefficient of 90%, a sample of 57 people is needed. The size of the sample was calculated in order to obtain statistically significant results in relation to the main variable, which is the quality of life.

2.7. Recruitment

The contact with possible participants and their recruitment for the study will be done through specific calls in the residences, requesting the collaboration of the users, and reference professionals.

Subsequently, presentation of the project to possible participants in the facilities of the residences will be carried out. All assistants will receive an information letter about concerns and performance of the research study.

In order to formalize their collaboration, the informed consent procedure will be carried out with participants who meet the inclusion criteria.

3. Methods: data collection, management, and analysis

The main variable assessed in the present study is the quality of life. Additionally, research group has been identified both general, common variables for the 3 research lines, and specific variables for each of the 3.

3.1. Data collection methods

The quality of life (QoL), the main study variable, will be determined with EuroQol-5D-5L. This descriptive system comprises 5 dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension has 5 levels: no problems, slight problems, moderate problems, severe problems, and extreme problems.[16] The EQ Visual Analog Scale (EQ VAS) records the patient's self-rated health on a vertical visual analogue scale. This can be used as a quantitative measure of health outcome that reflects the patient's own judgment. The scores on these 5 dimensions can be presented as a health profile or can be converted to a single summary index number (utility) reflecting preferability compared to other health profiles.[17] This tool is used in initial, periodic, and final assessments during the research project.

To get a general profile and complete the information about participants, a specific registry sheet was designed. On this sheet, sociodemographic and health data of the participants that may influence their quality of life are recorded: age, sex, marital status, educational level, main work activity, type of retirement, socioeconomic level, living environment, social support, use of assistive technology, diagnosis, and medication. This information will be consulted in the database of each residence or will be discussed with the elderly person, their relatives, or professionals.

The other general variables will be collected with the following methods:

- The Geriatric International Classification Functioning (ICF) Core Set: A comprehensive and valid set of 29 ICF categories, reflecting the most relevant health-related problems among community-living older adults. This consists of 35 items or categories which assess different conditions of health status. Each category is scored as 0, 1, 2, 3, 4, 8, or 9, except for the value of environmental factors, scoring on a scale as + 4, + 3, + 2, + 1, 0, 1, 2, 3, 4, 8, or 9. Environmental factors are scored as facilitators, barriers, or neutral elements.[18]
- Barthel Activities of Daily Living (ADL) Index: This tool has been used as a simple index of independence to score the ability of a patient to care for himself and by repeating the test periodically, to assess his improvement. The performance is assessed based on these scores: <20: total dependence, 20 to 40: severe dependence, 45 to 55: moderate dependence, and 60 or more: mild dependence. This tool is used in initial, periodic, and final assessments.[19]
- Tinetti Assessment Tool: A simple, easily administered test that measures a person's gait and balance. The test is scored on the individual's ability to perform specific tasks. "Scoring of the Tinetti Assessment Tool is done on a 3-point ordinal scale with a range of 0 to 2. A score of 0 represents the most impairment, while a score of 2 represents independence. The individual scores are then combined to form 3 measures; an overall gait

assessment score, an overall balance assessment score, and a combined gait and balance score." This tool is used in initial, periodic, and final assessments.[20]

- Mini-Mental State Examination (MMSE): This tool has been designed to determine the "cognitive state," that is one of the study's variables. It will be used for screening in order to verify 1 of the established exclusion criteria and in the initial, final, and follow-up evaluations. It presents 6 values: one for each section (Orientation, Fixation, Concentration and calculation, Memory and Language, and Construction) and final score.[21]
- Charlson Comorbidity Index (CCI): Predicts 10-year survival in patients with multiple comorbidities.[22]

To get data with respect to patient-specific characteristics in each 1 of the 3 research lines, additional instruments have been selected:

- Urinary incontinence:
  - Oxford Grading Scale: This scale measures the variable of "pelvic floor contractile capacity" and will be used for screening since a person who does not have contractile capacity cannot participate in the research line regarding urinary incontinence. It has a unique numerical value (0–5), that is the result from assessment of the contractile capacity of the pelvic floor muscles.[23]
  - Sandvick Severity Index: This test assesses the variable "urine leakage" and will be used for screening in order to assess the severity of urinary incontinence. It presents a unique numerical value and consists of 2 questions, one of them about the frequency with which a person has urine leakage (maximum score of 4 points) and another with reference to the amount of urine in the exhaust (maximum score of 3 points).[24]
  - IU4 Questionnaire: This tool helps to classify the type of urinary incontinence (UI). This scale has a unique qualitative value (4 different options). It is emphasized that question 1 identifies the effort of UI, while questions 2 and 3 identify the UI of urgency.[25]
  - 24-Hour Pad Test: This tool allows to measure the "amount of urine" and will be used in the initial, periodic, and final evaluations. This scale has three values (net weight of the napkin/diaper, weight with urine, and weight difference). The average of 3 days (one measurement per day) every 15 days will be carried out.[26]
  - PERFECT Scheme: The study variable that allows assessment of the "pelvic floor musculature" and will be used in the initial, periodic, and final evaluations. PERFECT is an acronym with P representing power (or pressure, a measure of strength using a manometric perineometer), E = endurance, R = repetitions, F = fast contractions, and finally ECT = every contraction timed. The scheme was developed to simplify and clarify PFM assessment.[27]
  - International Consultation on Incontinence Questionnaire (Short Form): The ICIQ-SF is a self-administered questionnaire that qualifies the symptoms and quality of life in both male and female adult patients with symptoms of urine loss.[28]
- Insomnia:
  - Oviedo Sleep Questionnaire: This scale consists of 13 items with 3 values: one for each section (sleep satisfaction, insomnia and hypersomnia). Each item is scored from 1 to 5, except for item 1 which is scored from 1 to 7. The subscale of insomnia ranges from 9 to 45 points; the higher the score the greater the severity.[29]
  - Pittsburgh Sleep Quality Assessment (PSQI): This is a self-report questionnaire that assesses sleep quality over a 1-month time interval. The measure consists of 19 individual items, creating seven components that produce 1 global score and takes 5 to 10 minutes to complete. The PSQI is intended to be a standardized sleep questionnaire for clinicians and researchers to use with ease and is used for multiple populations.[30]
- Risk of falls:
  - Timed Get Up and Go Test: A simple test used to assess a person's mobility and requires both static and dynamic balance. It uses the time that a person takes to rise from a chair, walk three meters, turn around, walk back to the chair, and sit down. During the test, the person is expected to wear their regular footwear and use any mobility aids that they would normally require.[31]
  - Falls Efficacy Scale International (FES-I): A short, easy to administer tool that measures the level of concern about falling during social and physical activities inside and outside the home whether or not the person actually does the activity. The level of concern is measured on a 4-point Likert scale (1 = not at all concerned to 4 = very concerned).[32]

3.2. Data management

To measure the efficacy of the multifactorial program, an initial assessment will be carried out before the intervention, in combination with periodic or follow-up evaluations. A final assessment will take place after the intervention and another one in 3 months after the end of the intervention. The tools used in the study, according to general research and specific research lines, are:

- General tools: EQ-5D-5L, CIF Basic set of Abbreviated Geriatric Patients, MEC, Barthel Index, and Tinetti Scale.
- Urinary incontinence: ICIQ-SF, PERFECT, and 24-Hour Pad Test.
- Insomnia: PSQI.
- Fall risk: Tinetti scale, Timed Get Up and Go, and FESI.

The confidentiality of all the data collected and the anonymity of each participant will be maintained. The data of the participants will be collected and preserved until the end of the study in coded mode. To do this, each participant will be assigned an alphanumeric code consisting of the letter P and a correlative number.

3.3. Statistical methods

The analysis of the data will be done with the statistical program SPSS. The quantitative variables will be expressed with the mean and the standard deviation, while the qualitative variables will be expressed as an absolute value and percentage.[33]

To compare the means, the student's *t* test will be used, and for the multiple comparisons of means, the analysis of the variance will be used. This test allows us to determine if the differences between the values of both variables are statistically significant or if they are differences due to chance. To study the association between qualitative variables, the χ^2 test will be used.

On the other hand, to determine the variables that are associated or not with the presence of the dichotomous variable of interest (Quality of Life), a multivariate logistic regression analysis will be performed, using as a dependent variable the presence or lack of presence of the event of interest, and as covariables, the variables that in the bivariate analysis are associated with the presence of said event or are clinically relevant.[33]

4. Ethics and dissemination

4.1. Research ethics approval

This study protocol has been approved by the host institution's ethics committee (Research Ethics Committee of Galicia) under the number 2017/106, with the date of [t] March 21, 2017.

The protocol is registered in ClinicalTrials.gov, with the reference number: NCT03504813

4.2. Protocol amendments

To communicate important possible amendments introduced in the protocol, a new request to the Research Ethics Committee of Galicia will be done, with the reference number assigned. Research group will wait for approval from this ethics committee in order to continue with the study. These amendments will also be updated in the registry of ClinicalTrials.

4.3. Consent or assent

With each participant, the process of informed consent will be applied. Participants will receive complete verbal and written information about characteristics of study and about the implications derived from their participation in it. The Information Sheet will be given to each participant so they can read it slowly and take the needed time to ask all questions that they have. Once it has been ensured that all participants fully understand the information provided, they will accept if they wish to participate in the study through the Informed Consent Document.

4.4. Confidentiality

The main researcher maintains the confidentiality of all data collected and the anonymity of each participant. Thus, the Spanish Organic Law on the protection of personal data will be respected at all times.

The data of the participants will be collected and preserved until the end of the study in coded mode.

4.5. Declaration of interests

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

4.6. Access to data

The custody of documentation that relates the identity of the participants with the coding will be the responsibility of the collaborating researchers. In this way, it is guaranteed that the rest of the researchers cannot know the identity of the participants at any time during the investigation. At the end of the project, the data will be anonymized.

4.7. Dissemination policy

Once the results and conclusions of the study have been extracted, they will be disseminated through the publication of scientific articles in international journals with high impact. The main investigator undertakes the publication of the results obtained, both negative and positive, and guarantees the anonymity of said data at all times.

5. Discussion

The development of this project represents an important innovation in the current scenario of patient-monitoring systems based on the Personal Health Record paradigm. The integration of characteristics of this paradigm in a single platform that allows, autonomously and freely, sharing and managing health information among patients, health professionals, and families is an innovative approach in European countries.

Other considerations that the project incorporates into this research field are:

- The development of intervention protocols for three areas of special concern for the elderly: urinary incontinence, the existence of falls, and insomnia.
- The conduction of a study which, by involving and empowering the elderly person in the control of their health, allows greater autonomy in this vital stage, decreasing continued external support.
- The adaptation of an App and interfaces for the elderly user who has some type of disability (cognitive, sensory, and/or physical).
- The integration of an App and wearables to verify, in real time, the execution of the proposed activities as an intervention.

In order to obtain more advances in this field and to complement the results derived from this study, we propose future lines of research:

- Clinical research: the important volume of health data that will be registered in the database will allow the information to be exploited to try to generate new knowledge. Applying data mining and big data techniques, it will be possible to obtain trend information and search for correlations between data, providing a basis for addressing research projects in health.
- Expanding the 3 research lines to other relevant areas in the aging of the population, for example, the prevention of cardiorespiratory problems, hearing loss, and so on.
- Conducting a clinical trial.
- Integrating into the solution wearable devices that come onto the market or devices of different types and/or brands, both in the national and international market and analyzing the data patterns in comparison with the patterns obtained in this project.

Author contributions

Conceptualization: Laura Nieto-Riveiro, Betania Groba, Carmen Miranda, Patricia Concheiro, Thais Pousada, Javier Pereira.
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Funding acquisition: Alejandro Pazos, Javier Pereira.
Investigation: Laura Nieto-Riveiro, Betania Groba, Carmen Miranda, Patricia Concheiro.
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Project administration: Laura Nieto-Riveiro, Javier Pereira.
Supervision: Alejandro Pazos, Javier Pereira.
Validation: Laura Nieto-Riveiro, Betania Groba, Alejandro Pazos, Javier Pereira.
Visualization: Betania Groba.
Writing – original draft: Thais Pousada.
Writing – review & editing: Thais Pousada.

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Estudo 2

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Review

Occupational Therapy and the Use of Technology on Older Adult Fall Prevention: A Scoping Review

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Abstract: *Introduction*: Falls are the second leading cause of accidental or non-intentional deaths worldwide and are the most common problem as people age. The primary purpose of addressing falls is to detect, prevent, treat, and reduce their incidence and consequences. Previous studies identified that multifactorial programs, an interprofessional team, and assistive technology are required to address falls in older adults effectively. Accordingly, the research question is as follows: what are the scope, type of studies, and approaches and strategies to fall risk using technology in the existing occupational therapy literature regarding interventions to address the effects of falls in older adults on daily living? *Methods*: This scoping review was carried out in January 2020 through *Biblioteca Virtual de Salud España*, C.I.N.A.H.L., Cochrane Plus, OTSeeker, PubMed, Scopus, and Web of Science. *Results*: Twelve papers were included. We analyzed the year and journal of publication, authors' affiliation, and design of the study, and thematic categories. There were three themes: participants' characteristics, type of intervention, and fall approach and type of technology used. *Discussion and Conclusions*: The literature obtained is scarce. It is considered to still be an emerging theme, especially when considering the use of technology for occupational therapy.

Keywords: older adults; falls; occupation; occupational therapy; scoping review; smart home technology; telehealth; exergames; 3D-application tool

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1. Introduction

The progressive aging of the population is a well-documented and projected theme of the 21st century, particularly in Europe and Japan [1–3]. Certain health conditions associated with the aging process lead to geriatric syndromes, including falls [4]. Current and past scientific evidence has identified falls as the second leading cause of accidental or non-intentional deaths worldwide and the most common and severe problem as people age [5–11]. Studies have shown that thirty percent of older adults suffer a fall annually, increasing to fifty percent for people aged eighty years and over, and this one of the primary causes of their hospitalization [5–11]. As people get older, they are more likely to fall. A recent study by Burton and colleagues [12] showed that the prevalence of falls has not changed in the last ten years.

Thus, the primary purpose of addressing falls, identified as a public health challenge, is to detect, prevent, treat, and reduce their incidence and consequences. There is a range of consequences from falls including a reduction in quality of life and increased socioeconomic costs. The consequences on quality of life can include decreased functional mobility, a decreased independence level, social restrictions, depression, loneliness, fear of falling and repeated falls [13–19].

Several factors can produce falls, and it is relevant to know these to aid in the detection process. According to the World Health Organization (WHO), intrinsic fall factors include factors mainly related to the aging process that affects the person. They also include factors that increased the risk of falls as living alone, taking some medicines (i.e., benzodiazepines) and having some medical conditions (i.e., cardiovascular diseases), impaired mobility and gait, sedentary behavior, fear of falling, nutritional deficiencies, impaired cognition, visual impairments, and foot problems [16]. On the other hand, extrinsic factors occur because older people often have problems with slipping or tripping, lack of good balance, or correction mechanisms to prevent falling. These factors include environmental hazards, unsuitable footwear and clothing, and inappropriate walking or assistive devices [16]. Fear of falling is a syndrome closely related to falls that can produce a fall [16,20]. Moreover, some studies have shown that around one-third of older adults develop a fear of falling after a fall [20,21].

Fall prevention is focused on injuries or complications that occur because of falling [12,22]. Numerous studies [23] have demonstrated that many falls can be prevented through adequate assessment and intervention. Some of the most common and effective interventions include [23] gait stabilizing footwear, vitamin D, dietary supplements, medication adaptation, multiple interventions, multifactorial interventions, assistive device training, cognitive monitoring and intervention, environmental modification, and family and caregiver training [24–29].

Different authors have also suggested that multifactorial programs are useful for preventing and reducing falls because of the complexity in the types of falls [30]. According to the World Health Organization (WHO), the risk of falls increases when multiple risk factors are present [16]. These multifactorial programs [30] involve a combination of exercise (focus on strength, balance and mobility), and other options such as individualized and comprehensive fall risk assessment about the person and, their environment and education on fall prevention. The GeriaTIC project is an example of using multifactorial interventions for fall prevention [31]. A study by Close and colleagues highlighted that an interprofessional approach to this high-risk population can significantly decrease the risk of further falls and limit functional impairment [32].

The effectiveness of these multifactorial programs is also based on the need to have an interprofessional team for fall prevention and treatment and geriatric approaches [33]. This includes a physician, a neurologist, a nurse, a psychiatrist, a physical therapist, and an occupational therapist. The latter is part of the non-pharmacological intervention [34,35]. Elliot and colleagues [36], in a systematic review, classified occupational therapy interventions on older adults' falls into three types of intervention that are shown in Table 1.

Table 1. Summary of occupational therapy interventions for falls in older adults.

	Summary of Occupational Therapy Interventions for Falls in Older Adults
Single component (includes only one of the following components)	Exercise
	Home safety assessment
	Education about falls' prevention
	Example: Lifestyle Integrated Functional Exercise study [37]
Multicomponent intervention (includes exercise and one of the following options)	1st option: educational components as:
	Feet or footwear risk
	Energy conservation strategies
	Safe assistive device use, home modification
	Fall recovery

Table 1. *Cont.*

	Summary of Occupational Therapy Interventions for Falls in Older Adults
	Medication routines
	Nutrition and hydration
	Relaxation stress management
	2nd option: home modification with other fall prevention intervention
	Example: Minimally Supervised Multimodal Exercise to Reduce Falls Risk in Economically and Educationally Disadvantaged Older Adults [38]
Multifactorial intervention (include the complex assessment of different components)	Fall risk
	Environment, education, and group activities
	Activities of daily living
	Assistive devices
	Self-efficacy or fear of falling
	Example: A single home visit by an occupational therapist reduces the risk of falling after hip fracture in elderly women: A quasi-randomized controlled trial [39]
Population-based fall prevention (includes strategies implemented across whole communities, two different types)	Existing effective population-based fall prevention programs
	Other population-based multicomponent interventions
	Example: Stepping On -Translating a Fall Prevention Intervention Into Practice: A Randomized Community Trial [40]

In addition to multifactorial programs and the interprofessional team, more emphasis is being placed on technology use. Technology has been integrated into some of the interventions for, or approaches to, fall reduction [18]. Assistive technology has been used to enable and promote inclusion and participation, maintain or improve functioning and independence, and promote well-being and active living [41–43].

According to the WHO [41], around the world, there are one billion people who require assistive products today. More than two billion people worldwide are expected to need at least one assistive product by 2030 [41]. Some examples of using assistive technology in older adults' falls interventions may include, video monitoring, health monitoring, electronic sensors, and equipment such as fall detectors, door monitors, bed alerts, pressure mats, and smoke and heat alarms, according to Miskelly and colleagues [42].

Also, remembering that exercise is the most common approach to falls, previous European projects such as the iStoppFalls [44], Farseeing [45] and Prevent IT [46] project were focused on using technology to improve older adults' physical functioning.

Accordingly, this study's primary goal is to explore the scope of occupational therapy literature regarding interventions to address the effects of falls in older adults on daily living with technology. Specifically, we intend to:

- Describe the types of studies on this topic and where they are usually published;
- Describe proposed occupational therapy approaches and strategies to fall risk using technology.

2. Materials and Methods

The authors conducted a scoping review in January 2020. The research questions that we aimed to answer were the following: what are the scope, type of studies, and approaches and strategies to fall risk using technology in the existing occupational therapy literature regarding interventions to address the effects of falls in older adults on daily living? Two approaches guided the present scoping review. On the one hand, the Arksey and O'Malley [47] five-stage framework was used, which includes stage 1 establishment of the research question; stage 2 identification of pertinent studies and choice of studies, stage 3 study selection as explained in Figure 1; and, as shown in the Results section, the stage 4 charting the data and stage 5 mapping the data and collating, summarizing, and reporting the findings. On the other hand, this scoping review also follows the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) (see Table S1 [48]. In accordance with the aim of a scoping review, a quality appraisal is not required, as opposed to Systematic reviews and Meta-Analyses [49].

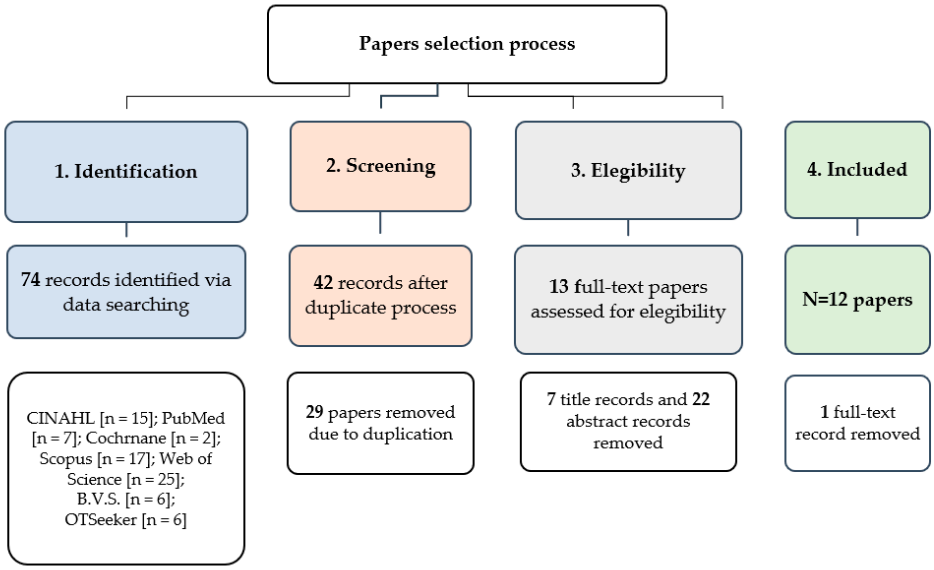

Figure 1. Flow diagram of the Scoping Review process.

2.1. Sources and Search Strategy

The search was focused on seven electronic databases (see supplementary Table S2 in the supplementary materials), specifically on health sciences and occupational therapy: *Biblioteca Virtual de Salud España* [50], C.I.N.A.H.L. [51], Cochrane Plus [52], OTSeeker [53], PubMed® [54], Scopus [55], and Web of Science [56].

The criteria used were flexible due to this being a current topic. The eligibility criteria were papers written in English, Portuguese, and/or Spanish; there was no limit on the year of publication; studies could only involve humans; and all types of documents (i.e., original articles, reviews, conference papers) were considered. Individual search strategies (see supplementary Table S2 in the supplementary materials) were used for each database using a combination of the operators "AND" and "OR," jointly with the criteria defined and the following descriptors:

- occupational therapy, ergotherapy;
- falls, accidental falls;
- aged, geriatrics, gerontology, older adult, older person, elder person, older people, elderly, elderly people, veteran, retired, senior;
- technology, technologies, wearable electronic devices, wearables, computers, digital games.

2.2. Study Selection and Data Extraction

After searching, in accordance with the PRISMA-ScR guidelines [48], the first step was to identify all of the records, which were imported into the bibliographic manager Mendeley [57]. The second step was screening, whereby duplications were removed through Mendeley [57]. In the eligibility step, the results were assessed by title, abstract, or full text, following the eligibility criteria defined and in accordance with the topic of interest—occupational therapy interventions based on technology to address falls in older adults (see supplementary Table S3 on supplementary materials). Thus, the studies had to involve falls, the older adult population, an occupational therapy perspective, and the use of technology. In total, 12 papers met the defined criteria. See the details of these processes in the Figure 1 in the Section 3.

2.3. Data Analysis

Data were compiled in Microsoft Excel® (Redmond, DC, USA) for validation, coding, and analysis. Bibliometric and thematic variables were used to analyze the characteristics of the studies. Frequencies and/or percentages were used to show the following bibliometric characteristics: year of publication, authors' affiliation, journal of publication, and type and design of the study. A thematic analysis was also conducted as a "*method for identifying, analyzing, and reporting patterns (themes) within data*" ([58], p. 79). According to Braun and Clarke "a theme captures something important about the data in relation to the research question, *and represents some level of patterned response or meaning within the data set*" ([58], p. 80). For this reason, the authors identified the following three themes: a description of the type of participants in study, types of intervention and approach to falls, and type of technology used.

3. Results

A total of 12 papers met the eligibility criteria and were included in the present Scoping Review. Figure 1 gives an explanation of the selection process for choosing these papers. Tables 2 and 3 summarizes the papers.

3.1. Bibliometric Characteristics

In total, we screened 74 documents, with 12 studies meeting the eligibility criteria (see Figure 1). The selected literature was published between 2012 and 2020. The first study to report the use of technology in an occupational therapy falls approach was published in 2012 [58].

The studies were conducted in the USA (n = 4) [58–61]; Europe (n = 6) [62–67], specifically in Scotland (n = 1) [62], Sweden (n = 1) [63], the UK (n = 3) [64,66,67], and Belgium (n = 1) [65]; and other countries such as Tunisia (n = 1) [68] and Australia (n = 1) [69].

The journals in which the articles were published were mainly those focusing on occupational therapy (n = 6) [58–62], particularly for the first publications of studies on the topic, and informatics and technological journals (n = 6) [64–69], which contained more of the recent studies.

The types of study were reviews—a systematic review (n = 1) [58] and a critical review (n = 1) [59] and original articles (n = 10) [59–61,67,68]. Within the original articles, there were different research designs. Quantitative approaches were used, including a descriptive study (n = 1) [66], a case study (n = 2) [60,61], and an experimental study (n = 1) [68]. The qualitative approaches used were qualitative research (n = 2) [63,69] and a mixed-methods study (n = 2) [65,66].

Table 2. Summary of data extracted from the 12 selected studies.

Author(s), Year, [Reference]	Authors' Affiliation	Journal of Publication	Type of Study and Purpose	Sample Characteristics (Size, Age, % of Female, Setting, and Others)	Technology Used	Main Findings
Chase, C.A.; Mann, K.; Wasek, S. and Arberman, M. 2012 [58]	Western Michigan University; Rehabilitation Hospital of Indiana; Ingham County Medical Center and Rehabilitation; University of Buffalo. U.S.A.	*Am. J. Occup. Ther.*	This systematic review aims to synthesize existing literature about the effect of home modification as both a separate intervention and a component of several fall prevention programs.	*n* = 33 studies, including a total of 31 randomized controlled trials Age = is focused on older adults (not specify ages) Setting = community-dwelling older adults Female = Number of females not specified	Commercially available smart home technology: operate lights, appliances, door, and windows for frail older adults living alone.	The results contribute to evidence-based practice for occupational therapy practitioners working with older adults in community-based settings and reinforce the importance of the role of occupational therapy in the home and community.
Stewart, L. and McKinstry, B. 2012 [62]	Astley Ainslie Hospital; Edinburgh University, Edinburgh	*Br. J. Occup. Ther.*	This critical review aimed to evaluate the association between older people's fear of falling and the use of telecare and whether telecare could reduce this fear.	*n* = 10 studies, including randomized controlled trials, a cohort study, two qualitative studies, a case study, and surveys Age = older adults over 60 years old Setting = older adults from public-assisted housing, day centers, and community living Female = Number of females not specified	Telecare: this is understood as the remote or enhanced delivery of health and social services to people in their own homes using telecommunications and computerized systems.	Telecare's contribution to supporting an aging population at home for longer is becoming increasingly recognized by health and social care services worldwide. However, this critical review identified that few studies are investigating older people's views and the use of telecare in the domain of occupational therapy.
Horowitz, B.; Nochajski, S.M. and Schweitzer, H.A. 2013 [59]	York College- CUNY; University of Buffalo; State University of New York. U.S.A.	*Occup. Ther. Health Care*	This case study focused on the development and pilot-testing of the Home Safety Self-Assessment Tool (H.S.S.A.T.), a new home assessment tool designed for use by older adults to promote home safety and aging.	*n* = 28 older adults Age = between 69 to 87 years old Female = 68% Setting = community dwelling	Videos: developed with instructions to install home modifications to prevent falls. Several tools were included to analyze the risks associated with older adults' homes in the project.	The results suggest the tool may assist older adults in identifying environmental factors related to falls and facilitate their ability to age in place.

Table 2. *Cont.*

Author(s), Year, [Reference]	Authors' Affiliation	Journal of Publication	Type of Study and Purpose	Sample Characteristics (Size, Age, % of Female, Setting, and Others)	Technology Used	Main Findings
Charness, *n*. 2014 [60]	Florida State University. U.S.A.	*Occup. Ther. Health Care*	This case study was used to illustrate telehealth as one important tool to improve the efficiency of healthcare delivery.	*n* = 9 older adults Age = older than 75 years Female = Number of females not specified Setting = community-dwelling	Telehealth system: consisting of a watch for a factor sensor system that monitors temperature with an analog display, an emergency button, and an accelerometer to provide information about activity and to monitor falls.	Telehealth systems can provide potentially important support for persons to live independently longer through automated monitoring. The purpose of this study was to find a cost-effective telehealth technology.
Bianco, M.L.; Pedell, S. and Renda, G. 2016 [69]	Swinburne University. Australia	*A.C.M.*	This qualitative research study assessed the perceptions of ten older adults on an augmented reality tool.	*n* = 10 older adults Age = between 69 and 92 years old with a mean age of 79.1 years Female = 60% Setting = not specified	An augmented reality application prototype on an iPad. The application is a 3D model library bank of typical and novel home modifications. Professionals can access this modification bank to superimpose a proposed recommendation into their client's home environment for evaluation and discussion.	The findings indicate that many older adults welcome augmented reality as a design and communication medium. It can be used as a bridging mechanism to increase the person-centeredness of fall prevention services.
Glannfjord, F.; Hemmingsson, H. and Larsson, A. 2016 [63]	Linkoping University. Sweden	*Scand. J. Occup. Ther.*	This qualitative (phenomenology) study examined how older adults perceive the Wii, namely the Wii sports bowling game, in an activity group.	*n* = between 10 and 12 Age = mean age of 78, between 64 and 98 years old Female = Number of females not specified Setting = Activity center for elderly people	The Nintendo Wii sports bowling game, with the Wii controller, was compared with real-life bowling.	The Wii was found to be an enjoyable and social activity. The interviewers looked forward to participating in the activity each week. Participants felt like they were really bowling in this virtual activity, and positive differences between regular bowling and virtual bowling were identified; virtual options were identified as being easier.

Table 2. *Cont.*

Author(s), Year, [Reference]	Authors' Affiliation	Journal of Publication	Type of Study and Purpose	Sample Characteristics (Size, Age, % of Female, Setting, and Others)	Technology Used	Main Findings
Hamm, J.; Money, G.A. 2017 [64]	Brunel University, London South Bank University. U.K.	*Health Informatics J.*	This mixed-study explored occupational therapists' perceptions of an early-stage, three-dimensional measurement aid prototype, which provides enhanced assistive equipment provision process guidance to clinicians.	*n* = 10 occupational therapists Female = 100% A ten pounds voucher was offered 2 to 31 years of experience. The occupational therapists' experience was in adults, social services, surgical rehabilitation, neurology, re-ablemen, and social services.	A 3D measurement aid prototype (3D-MAP) application, using 3D visualization technology was deployed on a tablet, mobile phone, or laptop. This was based on the five most commonly measured items with the Assistive Equipment Provision Process tool (bed, bath, toilet, chair, and stairs).	The results show that occupational therapists considered that the 3D-MAP application could effectively augment existing 2D diagrams and deliver numerous benefits.
Lemmens, R.; Gielen, C. and Spooren, A. 2017 [65]	P.X.L. University College. Belgium	*Stud. Health. Technol. Inform.*	This was a qualitative study about developing a screening tool to enable occupational therapists to assess people's home environments to facilitate independent living.	1st phase: *n* = 16 older adults in their homes Aged over 65 years old 2nd phase: *n* = 31 older adults Aged over 65 years old 3rd phase: *n* = 5 older adults, 5 informal caregivers, 5 professional caregivers Setting = community-dwelling The number of females was not specified	The Obstacle tool is a digitalized version using the mind maps and the paper version results for tablets. It has a version that can be used by health professionals or informal caregivers too. The digital version includes (1) the possibility of structuring the screening by adding the rooms in the order of preference for occupational therapists, (2) registration of problems/scores, (3) the addition of photos to the screening, (4) a better overview than in the paper version, (5) the option to store and save data and make a back-up, and (6) connection with the application H-OPP (a digital coach for occupational therapists).	The Obstacle tool was developed and judged to be very useful by occupational therapists. It was highlighted that the Obstacle is adapted for use for persons with dementia and a mini-obstacle tool is under construction and will be digitalized to be available for clients and their informal caregivers. The next step is to make the tool accessible to everybody.

Table 2. *Cont.*

Author(s), Year, [Reference]	Authors' Affiliation	Journal of Publication	Type of Study and Purpose	Sample Characteristics (Size, Age, % of Female, Setting, and Others)	Technology Used	Main Findings
Arthanat, S.; Wilcox, J. and Macuch, M. 2019 [61]	The University of Hampshire. U.S.A.	*O.T.J.R.*	This descriptive study aimed to determine the extent to which smart home technology has been adopted by older adults, what types of smart home devices are being used, the health factors related to the adoption of this technology, and the factors that contribute to smart homeownership and readiness.	*n* = 445 older adults Age = a mean age of 70.7, between 60 and 95 years old Setting = community dwelling Female = 68%	Smart Home Technology: sensor networks to monitor and gather information about the state of the home and its residents, mechanisms that allow communication between devices to enable automation and remote access, and user interfaces such as home displays, personal computers, tablets, and smartphones to enable consumers to set preferences/goals and receive information and feedback.	The present study concluded that adoption and interest in smart home technology are relatively low among older adults. The levels of ownership and readiness vary vastly by technology, demographic segments, functional status, and home safety. These aspects could be taken into account by occupational therapists.
Hamm, J.; Money, A.G. and Atwal, A. 2019 [66]	Brunel University, London South Bank University. U.K.	*J. Biomed. Inform.*	This mixed-method study aimed to present a 3D mobile application to enable older adults to carry out self-assessment measurement tasks in accordance to two different treatment conditions, using a 3D guidetomeasure tool or a 2D paper-based guide.	*n* = 37 participants Age = mean age of 68.5, between 55 and 86 years old (20 retired, 11 employed, three not specified) Female = Not specified Setting = Not specified	The application 3D guidetomeasure-3D was developed by the Unity3D game engine, which supports multi-platform deployment, including Android, IOS, desktops, and Web. The unity3D engine includes an avatar model, 3D furniture models, and arrow prompts of the application.	An empirical mixed-methods assessment of the performance of the guidetomeasure-3D application revealed that, in terms of accuracy, consistency, task completion time, and usability, significant performance gains were achieved over the art's current state paper-based 2D measurement guide equivalent.

Table 2. *Cont.*

Author(s), Year, [Reference]	Authors' Affiliation	Journal of Publication	Type of Study and Purpose	Sample Characteristics (Size, Age, % of Female, Setting, and Others)	Technology Used	Main Findings
Money, A.G.; Atwal, A.; Boyce, E.; Gaber, S.; Windeatt, S. and Alexandrou, K. 2019 [67]	Brunel University U.K.	*B.M.C. Med. Inform. Decis. Mak.*	This mixed-method study used Falls Sensei 3D to evaluate the overall game usability from an older adult perspective and to explore older adults' perceptions of using Falls Sensei, the factors affecting the adoption of this application, and the extent to which the modification of fall-prevention-related behavior can occur as a consequence of playing the Falls Sensei game.	*n* = 15 participants Age = between 50 and 80 years old Setting = adults attending a 50s gym group on a university campus Female = 60%	Falls Sensei 3D game is a first-person 3D exploration game with four levels that correspond to four key living areas within the home: the kitchen, bathroom, bedroom, lounge, and stairs. The application was developed with Unity3D to generate a GameObject, which contains 3D Models and associated scenes presented at each game level.	This study offers a promising exploration into using challenging games to address extrinsic factors in fall risk reduction. Data analysis triangulation suggests that the game raised awareness of home hazard detection, but further research is needed to draw comparisons with established interventions.
Haj, A. B. and Khalfallah, A. 2020 [68]	The University of Sfax. Tunisia	*Smart Innovation, Systems, and Technologies. Book Series*	This experimental study aimed to propose an exercise to improve patients' posture with the use of Kinect.	One older adult No details were specified	Kinect is designed to control video games while allowing human–machine interaction without markers or a joystick. The body interacts with the machine. Kinect allows the acquisition of RGB video, a depth map, and sound through the libraries supplied with the software kit. Kinect includes two cameras—RGB and depth, a 3D camera that enables 3D motion capture, and a microphone.	This study has limitations because the Kinect sensor has limitations in precision compared with other more expensive motion 3D sensors. The authors recommend that this exercise is used by older people who do not suffer from dizziness, neurological disorders, or severe pathological diseases.

3.2. Thematic Categories

3.2.1. A Description of the Type of Participants in Study

This theme was about the types of participants included in the studies (i.e., older adult(s) or occupational therapist(s)), the age of the participants, the percentage of females in the sample, the environment in which the study was conducted (i.e., community-dwelling or an institution), and other interesting details mentioned.

The reviews included in this study did not provide some of the participants' characteristics (see Table 3 details of the participants). In a review by Chase and colleagues [58], a total of thirty-three studies were included, all randomized controlled trials, while in the review by Stewart and colleagues study [62], ten studies were included and these were different types of studies.

The original articles [59–61,63–65,67–69] included 614 older adults, 15 occupational therapists, and 5 informal caregivers. The samples size of the studies included 1 ($n = 1$) [68] to 445 ($n = 1$) older adults [61], 1 ($n = 7$) [59–61,63,66,67,69] to 10 ($n = 1$) types of occupational therapy [64], and 1 ($n = 9$) to 5 ($n = 1$) informal caregivers [65]. There was a large age range age of older adults from 50 years old ($n = 1$) [67] to a maximum of 98 years old ($n = 1$) [63]. These people were recruited from the community ($n = 8$) [59–61,65], an activity center for older adults ($n = 1$) [63], or people attending a gym group on a university campus ($n = 1$) [67]. Regarding the percentage of females, all studies included more females than males, with a percentage of females of between 60 ($n = 2$) [64,69] and 68% ($n = 2$) [59,61]. One hundred percent of the occupational therapists were female [64].

All participants volunteered to participate in the different studies, but in the study by Hamm and colleagues, the occupational therapists received a ten pound voucher [64].

3.2.2. Type of Intervention and Approach to Falls

This theme included the type of intervention if the study was about a specific risk factor related to falls (extrinsic, alien to the individual, or intrinsic, related to the person and the aging process) and the type of approach to falls (detection, prevention, or treatment).

Four types of intervention were identified: "home modifications" ($n = 5$) [59,64–66,69], "assistive technology" ($n = 4$) [58,60–62], "exercise" ($n = 2$) [63,68], and "educational" ($n = 2$) [59,67]. We considered single-component interventions and focused on fall detection, prevention, and treatment. Interventions that focused on home modification addressed extrinsic factors such as bathroom modifications (i.e., bath, toilet, shower), appropriate chair height, and indications to include space to move, among others. Assistive technology interventions addressed extrinsic factors that can affect the safety of the person in the home. This included the use of telecare, emergency alarms, and fall detectors (i.e., pendant alarms). Exercise was used as a strategy to address intrinsic factors related to physical condition and the use of educational interventions in these studies was based on extrinsic factors, which consisted of the types of modification the person has to do to be safe at home.

3.2.3. Type of Technology Used

This theme was about the types of technology addressed in the studies. The technologies used in the studies were classified as software developments, telehealth, multimedia materials, and commercial and technological devices. Software developments ($n = 5$) included augmented reality applications [69], 3D measurement aid prototype applications [64,66], a digital version of the Obstacle Tool [61], and a Falls Sensei 3D game [67]. The use of telehealth was integrated into telecare to reduce the fear of falling [62], and the system was integrated into a watch to provide a factor sensor system to monitor temperature with an analog display, an emergency button, and an accelerometer [60]. The multimedia materials included different videos to identify environmental fall factors [59]. The commercial and technological devices included smart home technology to operate lights, appliances, doors, and windows [58], and these included the use of Kinect [68] and Nintendo Wii [63].

Table 3 shows the relationships between Section 3.2.2 (Type of intervention and approach to falls) and Section 3.2.3 (Type of technology used, and the compatibility of the technology used with the technological devices: Tablet, iPad, computer, laptop, Xbox, Nintendo Wii, and mobile phone).

Table 3. Relationships between Section 3.2.2. and Section 3.2.3.

Types of Technology	Technology Used	Compatibility	Intervention	Falls Risk
Software developments	Augmented reality application	iPad	Home modifications	Extrinsic factors
	3D measurement aid prototype application	Tablet, mobile phone, or laptop		
	Digital version of Obstacle Tool	Tablet		
	Falls Sensei 3D game	Computer		
Telehealth	Telehealth system	Not applied	Assistive technology	Extrinsic factors
	Telecare			
	Smart home technology			
Multimedia materials	Videos	Computer, laptop, mobile phone or Tablet	Educational	Extrinsic factors
Commercial and technological devices	Kinect with Xbox and Nintendo Wii	Kinect with Xbox and Nintendo Wii	Exercise	Intrinsic factors

4. Discussion

This study presents the first scoping review of occupational therapy interventions to address older adults' falls using technology. The objectives defined focused on exploring the literature about the topic to determine the type of studies conducted, where these studies have usually been published, and the approaches and strategies used to reduce fall risk by occupational therapists using technology.

The results show that this is an emerging area, which began to be researched in the year 2012 [58]. In a review by Chase and colleagues on home modification, only telecare was mentioned as a possible strategy by occupational therapists, but occupational therapists did not specifically develop that study. However, previous studies focused on the use of technology. For example, the iStoppFalls project focused on the use of exergames to reduce falls in older adults; this project was conducted from 2011 to 2014 to motivate and enhance the use of physical activity by community-dwelling adults aged more than sixty-five years by engaging with three purpose-built exergames to reduce falls [43,70].

The present review shows a trend toward carrying out studies with a qualitative approach [63,69] and mixed-methods studies [65,66], reinforcing the idea that is important to understand the perceptions and opinions of the older adults or occupational therapists and other health professionals under study to find out about their experiences with using the technology. This type of research helps us to understand the acceptance or not of technology and to determine how to improve or adapt it to make it useful in older people's day-to-day lives [71].

Regarding the place of publication, similar numbers of studies have been carried out in the USA [58–61] and Europe [62–67], even though progressive aging of the population is more apparent in Europe, and considering that previous European projects such as Prevent IT, Farseeing, and iStoppFalls, which are an essential background to fall prevention and the use of technology, were developed in Europe [43–45].

Compared with other reviews about falls and occupational therapy [41,69], the present scoping review results are of a lower research quality, because it was not possible to find any controlled trials to demonstrate the effectiveness of the interventions developed alongside technology. The types of studies included descriptive studies [61], case studies [59,60], experimental studies [68], and qualitative studies [63,69], which are not considered to give a high level of evidence. Instead, some controlled trials were carried out in the field of falls and occupational therapy, for example, the one by Monaco and colleagues [39].

As for the participant sample sizes and characteristics, the samples used were relatively small, except for one case [61]. This is linked to the level of evidence mentioned above and the types of study used. The types of participant included older adults, occupational therapists, and/or informal caregivers.

Only one of the types of software developed, obstacle tool digitalization [65], was tested in older adults, occupational therapists, and informal caregivers. The aim was to make it accessible for everybody, which is an essential factor to keep in mind in software development, according to the accessible software development model [72], the philosophy of design for all [73], and the inclusive perspective of the occupational therapy [74], as this helps to break the digital divide, particularly among older adults [74].

The studies included an extensive range of ages from 50 [67] to 98 years old [63], although older persons are classified as those aged 65 or more years. This reflects the perspective of preventing falls in people nearing retirement and the importance of active, healthy aging throughout life [75,76]. The life expectancy in Europe and USA, the main places of publication, is approximately 82 years old [74]. Life expectancy at age sixty is higher in women than men [77], and as can be seen in the results, females made up the highest percentage of participants in the studies, with 60–68% of participants being older women [67,69].

Regarding the type of intervention used to address falls in older adults through occupational therapy, only single-component interventions were used [36], even though different authors have suggested that multifactorial programs help to prevent and reduce falls because of their complexity [30]. None of the studies included an interprofessional team, despite its importance. The effectiveness of the multifactorial programs is also due to the use of an interprofessional team for fall prevention and treatment [33].

In terms of multifactorial programs [30], these involved exercise, as was done in two studies included in this review [63,68]; individualized and comprehensive fall risk assessment about the environment of an older adult, as done in a few studies mentioned in this review [59,64–66,69]; and education on fall prevention, as done in two studies [60,68]. Furthermore, any intervention includes occupational therapy home visits [78], which can be an essential aspect to include, especially in the cases of home modification [59,64–66,69] and assistive technology [58,60–62]. The studies that integrated aging in place focused on assistive technology and home modifications because these factors are widely acknowledged as being the primary and preferred interventions during ageing [79,80]. Understanding how older people's needs contribute to improving their quality of life, which is affected after a fall, is necessary [13–16,18,19].

A previous systematic review explored the cost-effectiveness of several occupational therapy interventions for older people, concluding that they are useful and cost-effective compared with standard care or other therapies [81]. In this way, socioeconomic impact is one of the consequences of falls [28]. However, the results were not focused on aspects related to socioeconomic impact.

Our results reinforce the idea that home modifications, assistive technology, and educational interventions can address extrinsic factors, particularly environmental factors, and exercise can address intrinsic factors. This is in accordance with previous studies about the use of occupational therapy interventions to address fall risk [24,82–85].

Although, as mentioned above, some examples of assistive technology used to prevent falls in older adults include video-monitoring, health monitoring, electronic sensors, and fall detectors [42] these were not included in the studies mentioned in this review. Moreover, regarding fall interventions globally, there is more focus on exercise options and an extensive range of technologies from virtual reality [86] to wearables [87] that were not included in these studies. Primarily, virtual reality interventions are used in occupational therapy, for example, in children [86].

As a result of this review, it is suggested that researchers in this field perform more studies that include the latest technology in the field of falls, so that more studies with a higher level of evidence exist. Interprofessional and multifactorial interventions should be integrated.

Limitations

The present scoping review has few limitations since all those publications related to the topic have been included; regarding the language were included articles in English, Spanish, and Portuguese; and regarding the type of study, any of them were included. The first limitation maybe not including other languages or other databases in the search process. However, we included databases of occupational therapy and socio-health care. Regarding the searches and the inclusion and exclusion of studies, it was carried out by one of the authors, which may be a limitation. In spite that the researcher used a structured process, some data may have been omitted or excluded. As future research, it would be important to integrate more researchers into this process.

5. Conclusions

Although falls have been identified as a public health challenge and the importance of technology in our lives is well known, the literature available on the prevention of falls in older adults using technology is scarce. It is considered to be an emerging area, especially when considering the use of technology in occupational therapy.

The studies in this area have mainly been conducted in the USA and Europe and have been published in occupational therapy and informatics journals. The target population is those over 50 years of age. The risk factors that have most frequently been evaluated and considered are extrinsic factors, particularly environmental factors. Interventions on occupational therapy using technology to address falls in older adults have been single component methods, including home modifications, assistive technology, educational intervention, and exercise. The technology used in the studies can be classified as software developments, telehealth, multimedia material, and commercial technological devices. Lastly, the authors conclude that the prevention of falls in older adults is an essential part of interventions against the risk of falls, and occupational therapy and the use of technology may contribute greatly to interprofessional fall prevention programs.

Supplementary Materials: The following are available online at https://www.mdpi.com/1660-4601/18/2/702/s1, Table S1: Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist. Table S2: Search strategies from each database, Table S3: Removed from eligibility criteria.

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Supplementary materials

Table S2. Search strategies from each database.

Database	Search Term Used	Results	Date
CINAHL	(("Occupational Therapy" OR ergotherapy) AND ("Accidental Falls" OR "Falls") AND ("Aged" OR "Geriatrics" OR "Older Adult" OR "Older Person" OR "Elderly" OR "Elderly People" OR "Veteran" OR "Retired" OR "Senior" OR "Older People" OR "Elder Person" OR "Gerontology") AND ("Technolog*" OR "Computers" OR "Wearables" OR "Digital games")) Language = English	15	08/01/2020
PubMed	((("Occupational Therapy"[Mesh] OR "Occupational therapy"[Title/Abstract] OR ergotherapy [Title/Abstract])) AND ("Accidental Falls"[Mesh] OR "Accidental Falls"[Title/Abstract] OR "Falls"[Title/Abstract])) AND ("Aged"[Mesh] OR "Aged"[Title/Abstract] OR "Geriatrics"[Mesh] OR "Geriatrics"[Title/Abstract] OR "Older Adult"[Title/Abstract] OR "Older Person"[Title/Abstract] OR "Elderly"[Title/Abstract] OR "Elderly People"[Title/Abstract] OR "Veteran"[Title/Abstract] OR "Retired"[Title/Abstract] OR "Senior"[Title/Abstract] OR "Older People"[Title/Abstract] OR "Elder Person"[Title/Abstract] OR "Gerontology"[Title/Abstract])) AND ("Technology"[Mesh] OR "Technology"[Title/Abstract] OR "Computers"[Mesh] OR "Computers"[Title/Abstract] OR "wearable electronic devices"[Mesh] OR "wearable electronic devices" [Tittle/Abstract] OR "digital games"[Tittle/Abstract] OR "technologies"[Tittle/Abstract]) AND (English[lang] OR Portuguese[lang] OR Spanish[lang]) AND (Clinical Trial[ptyp] OR Review[ptyp] OR systematic[sb] OR Journal Article[ptyp] OR Congress[ptyp])	7	08/01/2020
Cochrane	(("Occupational Therapy" OR ergotherapy) AND ("Accidental Falls" OR "Falls") AND ("Aged" OR "Geriatrics" OR "Older Adult" OR "Older Person" OR "Elderly" OR "Elderly People" OR "Veteran" OR "Retired" OR "Senior" OR "Older People" OR "Elder Person" OR "Gerontology") AND ("Technolog*" OR "Computers" OR "Wearables" OR "Digital games")) en Título Resumen Palabra clave - (Se han buscado variaciones de la palabra)	2	08/01/2020
Scopus	(TITLE-ABS-KEY ("Occupational Therapy" OR ergotherapy) AND TITLE-ABS-KEY ("Accidental Falls" OR "Falls") AND TITLE-ABS-KEY ("Aged" OR "Geriatrics" OR "Older Adult" OR "Older Person" OR "Elderly" OR "Elderly People" OR "Veteran" OR "Retired" OR "Senior" OR "Older People" OR "Elder Person" OR "Gerontology") AND TITLE-ABS-KEY ("Technolog*" OR "Computers" OR "Wearables" OR "Digital games")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re") OR LIMIT-TO (DOCTYPE , "cp")) AND (LIMIT-TO (LANGUAGE , "English"))	17	08/01/2020
Web of Science	TEMA: ("Occupational therapy" OR ergotherapy) AND TEMA: ("Accidental falls" OR Falls) AND TEMA: (Aged OR Geriatrics OR "Older adult" OR "Older person" OR Elderly OR "Elderly people" OR Veteran OR Retired OR Senior OR "Older people" OR "Elder person" OR "Gerontology") AND TEMA: (Technolog* OR Computers OR Wearables OR "Digital games")	25	08/01/2020
BVS	"terapia ocupacional" AND caídas AND mayores AND tecnología	6	08/01/2020
OTSeeker	"occupational therapy" AND "falls" AND "technology"	1	08/01/2020

Table S3. Removed from eligibility criteria.

	Tittle	Abstract	Full Text
1. The Emergency Department Stopping Elderly Accidents, Deaths and Injuries Program - Full Text View - ClinicalTrials.gov. (n.d.). Retrieved January 8, 2020, from https://clinicaltrials.gov/ct2/show/NCT02167737.		Occupational therapy, falls and technology are not included	
2. Proceedings of the 3rd IPLeiria's International Health Congress: Leiria, Portugal. 6-7 May 2016. (2016). BMC Health Services Research, 16 Suppl 3, 200. https://doi.org/10.1186/s12913-016-1423-5.	This paper are not available		
3. Effectiveness of one home visit by an occupational therapist in the prevention of falls: A quasi-randomized controlled trial in elderly women who sustained a hip fracture Fonte: Calcified Tissue International [0171-967X] Di Monaco, M ano: 2008 vol:82 px:S222 - S222. (2008). Retrieved from https://link.springer.com/journal/volumesAndIssues/223.		Technology is not included	
4. Bathroom safety: Environmental modifications to enhance bathing and aging in place in the elderly. (n.d.). Retrieved January 8, 2020, from https://www.researchgate.net/publication/289860337_Bathroom_safety_Environmental_modifications_to_enhance_bathing_and_aging_in_place_in_the_elderly.		Technology is not included	
5. Arthanat, S., Wilcox, J., & Macuch, M. (2019). Profiles and Predictors of Smart Home Technology Adoption by Older Adults. OTJR Occupation, Participation and Health, 39(4), 247–256. https://doi.org/10.1177/1539449218813906.			Accepted
6. Ben Haj Khaled, A., Khalfallah, A., & Bouhlel, M. S. (2020). Fall Prevention Exergame Using Occupational Therapy Based on Kinect. Smart Innovation, Systems and Technologies, 146, 479–493. https://doi.org/10.1007/978-3-030-21005-2_46.			Accepted
7. Bernardo, L. D. (2018). Older adults with Alzheimer's disease: A systematic review about the Occupational Therapy intervention in changes of performance skills. Brazilian Journal of Occupational Therapy, 26(4), 926–942. https://doi.org/10.4322/2526-8910.ctoAR1066.			Falls are not included
8. Bleijlevens, M. H. C., Hendriks, M. R. C., Van Haastregt, J. C. M., Crebolder, H. F. J. M., & Van Eijk, J. T. M. (2010). Lessons learned from a multidisciplinary fall-prevention programme: The occupational-therapy element. Scandinavian Journal of Occupational Therapy, 17(4), 319–325. https://doi.org/10.3109/11038120903419038.		Technology is not included	
9. Bleijlevens, M. H., Hendriks, M. R., van Haastregt, J. C., van Rossum, E., Kempen, G. I., Diederiks, J. P., … van Eijk, J. T. (2008). Process factors explaining the ineffectiveness of a multidisciplinary fall prevention programme: A process evaluation. BMC Public Health, 8(1), 332. https://doi.org/10.1186/1471-2458-8-332.		Technology is not included	
10. Briggs, R., & O'Neill, D. (2014, March 1). Vascular gait dyspraxia. Clinical Medicine, Journal of the Royal College of Physicians of London, Vol. 14, pp. 200–202. https://doi.org/10.7861/clinmedicine.14-2-200.	Falls, older adults,		

	technology and occupational therapy are not included		
11. Chang, Y. W., Chang, Y. H., Pan, Y. L., Kao, T. W., & Kao, S. (2017). Validation and reliability of Falls Risk for Hospitalized Older People (FRHOP). Medicine (United States), 96(31). https://doi.org/10.1097/MD.0000000000007693.		Technology is not included	
12. Charness, N. (2014). Utilizing Technology to Improve Older Adult Health. Occupational Therapy In Health Care, 28(1), 21–30. https://doi.org/10.3109/07380577.2013.865859.			Accepted
13. Chase, C. A., Mann, K., Wasek, S., & Arbesman, M. (2012). Systematic Review of the Effect of Home Modification and Fall Prevention Programs on Falls and the Performance of Community-Dwelling Older Adults. American Journal of Occupational Therapy, 66(3), 284–291. https://doi.org/10.5014/ajot.2012.005017.			Accepted
14. Connell, B. R. (1996). Role of the environment in falls prevention. Clinics in Geriatric Medicine, Vol. 12, pp. 859–880. https://doi.org/10.1016/s0749-0690(18)30205-2.		Technology is not included	
15. Faes, M. C., Reelick, M. F., Esselink, R. A., & Rikkert, M. G. O. (2010, November). Developing and evaluating complex healthcare interventions in geriatrics: The use of the medical research council framework exemplified on a complex fall prevention intervention. Journal of the American Geriatrics Society, Vol. 58, pp. 2212–2221. https://doi.org/10.1111/j.1532-5415.2010.03108.x.		Occupational therapy is not included	
16. Ganesh, S., Hayter, A., Kim, J., Sanford, J., Sprigle, S., & Hoenig, H. (2007). Wheelchair Use by Veterans Newly Prescribed a Manual Wheelchair. Archives of Physical Medicine and Rehabilitation, 88(4), 434–439. https://doi.org/10.1016/j.apmr.2006.12.045.	Falls are not included		
17. Gately, M. E., Trudeau, S. A., & Moo, L. R. (2019). Feasibility of Telehealth-Delivered Home Safety Evaluations for Caregivers of Clients With Dementia. OTJR Occupation, Participation and Health. https://doi.org/10.1177/1539449219859935.		Occupational therapy is not included	
18. Gaugler, J. E., & Kane, R. L. (2015). Family Caregiving in the New Normal. In Family Caregiving in the New Normal. https://doi.org/10.1093/geront/gnv333.06.	Falls, older adults, occupational therapy and technology are not included		
19. Glännfjord, F., Hemmingsson, H., & Larsson Ranada, Å. (2017). Elderly people's perceptions of using Wii sports bowling–A qualitative study. Scandinavian Journal of Occupational Therapy, 24(5), 329–338. https://doi.org/10.1080/11038128.2016.1267259.			Accepted
20. Hamm, J., Money, A. G., & Atwal, A. (2019). Enabling older adults to carry out paperless falls-risk self-assessments using guidetomeasure-3D: A mixed methods study. 92, 103135. https://doi.org/10.1016/j.jbi.2019.103135.			Accepted

21. Hamm, J., Money, A. G., Atwal, A., & Ghinea, G. (2019). Mobile three-dimensional visualisation technologies for clinician-led fall prevention assessments. Health Informatics Journal, 25(3), 788–810. https://doi.org/10.1177/1460458217723170.		Accepted
22. Horowitz, B. P., Nochajski, S. M., & Schweitzer, J. A. (2013). Occupational therapy community practice and home assessments: use of the home safety self-assessment tool (HSSAT) to support aging in place. Occupational Therapy in Health Care, 27(3), 216–227. https://doi.org/10.3109/07380577.2013.807450.		Accepted
23. Intiso, D., Di Rienzo, F., Russo, M., Pazienza, L., Tolfa, M., Iarossi, A., & Maruzzi, G. (2012). Rehabilitation strategy in the elderly. Journal of Nephrology, 25(SUPPL.19). https://doi.org/10.5301/jn.5000138.	Occupational therapy is not included	
24. King, E. C., & Novak, A. C. (2017). Effect of bathroom AIDS and age on balance control during bathing transfers. American Journal of Occupational Therapy, 71(6). https://doi.org/10.5014/ajot.2017.027136.	Technology is not included	
25. Krishnan, S., Pappadis, M. R., Weller, S. C., Fisher, S. R., Hay, C. C., & Reistetter, T. A. (2018). Patient-centered mobility outcome preferences according to individuals with stroke and caregivers: a qualitative analysis. Disability and Rehabilitation, 40(12), 1401–1409. https://doi.org/10.1080/09638288.2017.1297855.	Occupational therapy, falls, older adults and technology is not included	
26. Layton, N., Clarke, A., & Pennock, J. (2014, December 1). "Doing with not doing for": a paradigm shift in home care services and what it means for occupational therapy. Australian Occupational Therapy Journal, Vol. 61, pp. 11–13. https://doi.org/10.1111/1440-1630.12184.	Technology is not included	
27. Lemmens, R., Gielen, C., & Spooren, A. A tool to assess. , 242 § (2017).		Accepted
28. Lo Bianco, M., Pedell, S., & Renda, G. (2016). Augmented reality and home modifications: A tool to empower older adults in fall prevention. Proceedings of the 28th Australian Computer-Human Interaction Conference, OzCHI 2016, 499–507. https://doi.org/10.1145/3010915.3010929.		Accepted
29. Mackenzie, L., & Clifford, A. (2020). Perceptions of older people in Ireland and Australia about the use of technology to address falls prevention. Ageing and Society, 40(2), 369–388. https://doi.org/10.1017/S0144686X18000983.	Occupational therapy is not included	
30. Mao, H. F., Chang, L. H., Tsai, A. Y. J., Huang, W. N., & Wang, J. (2016). Developing a referral protocol for community-based occupational therapy services in Taiwan: A logistic regression analysis. PLoS ONE, 11(2). https://doi.org/10.1371/journal.pone.0148414.	Technology is not included	
31. Mengshoel, A. M., & Skarbø, Å. (2017). Rehabilitation needs approached by health professionals at a rheumatism hospital. Musculoskeletal Care, 15(3), 210–217. https://doi.org/10.1002/msc.1162.	Older adults, falls, occupational therapy and technology	

	are not included		
32. Money, A. G., Atwal, A., Boyce, E., Gaber, S., Windeatt, S., & Alexandrou, K. (2019). Falls Sensei: A serious 3D exploration game to enable the detection of extrinsic home fall hazards for older adults. BMC Medical Informatics and Decision Making, 19(1). https://doi.org/10.1186/s12911-019-0808-x.			Accepted
33. Pighills, A., Drummond, A., Crossland, S., & Torgerson, D. J. (2019). What type of environmental assessment and modification prevents falls in community dwelling older people? BMJ (Online), 364. https://doi.org/10.1136/bmj.l880.		Technology is not included	
34. Plow, M., & Finlayson, M. (2014). A qualitative study exploring the usability of nintendo wii fit among persons with multiple sclerosis. Occupational Therapy International, 21(1), 21–32. https://doi.org/10.1002/oti.1345.	Older adults are not included		
35. Roach, J., Singh, J., & Pusalkar, P. (2012). Elderly patients with conservatively managed subdural haemorrhage should have a follow-up plan. QJM, 105(12), 1201–1203. https://doi.org/10.1093/qjmed/hcr140.	Occupational therapy, technology and falls are not included		
36. Sanders, M. J., O'Sullivan, B., DeBurra, K., & Fedner, A. (2013). Computer Training for Seniors: An Academic-Community Partnership. Educational Gerontology, 39(3), 179–193. https://doi.org/10.1080/03601277.2012.700816.		Falls are not included	
37. Sheffield, C., Smith, C. A., & Becker, M. (2013). Evaluation of an agency-based occupational therapy intervention to facilitate aging in place. Gerontologist, 53(6), 907–918. https://doi.org/10.1093/geront/gns145.		Technology is not included	
38. Sipilä, S., Tirkkonen, A., Hänninen, T., Laukkanen, P., Alen, M., Fielding, R. A., … Törmäkangas, T. (2018). Promoting safe walking among older people: The effects of a physical and cognitive training intervention vs. physical training alone on mobility and falls among older community-dwelling men and women (the PASSWORD study): Design and methods of a randomized controlled trial. BMC Geriatrics, 18(1). https://doi.org/10.1186/s12877-018-0906-0.		Occupational therapy and technology are not included	
39. Somerville, E., Smallfield, S., Stark, S., Seibert, C., Arbesman, M., & Lieberman, D. (2016). Occupational Therapy Home Modification Assessment and Intervention. American Journal of Occupational Therapy, 70(5), 7005395010p1. https://doi.org/10.5014/ajot.2016.705002.		Technology is not included	
40. Steultjens, E. M. J., Dekker, J., Bouter, L. M., Jellema, S., Bakker, E. B., & van den Ende, C. H. M. (2004, September). Occupational therapy for community dwelling elderly people: A systematic review. Age and Ageing, Vol. 33, pp. 453–460. https://doi.org/10.1093/ageing/afh174.		Technology and falls are not included	
41. Stewart, L. S. P., & McKinstry, B. (2012). Fear of Falling and the Use of Telecare by Older People. British Journal of Occupational Therapy, 75(7), 304–312. https://doi.org/10.4276/030802212X13418284515758.			Accepted
42. Wahl, H. W., Fänge, A., Oswald, F., Gitlin, L. N., & Iwarsson, S. (2009). The home environment and disability-related outcomes in aging individuals: What is the empirical evidence? Gerontologist, 49(3), 355–367. https://doi.org/10.1093/geront/gnp056.		Technology is not included	

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	1-3
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	3
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	-
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	4
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	3-4
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Suplementary material
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	4-5
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	4
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	4
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	4
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	4

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SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	4-5
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	8-13
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	5-7
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	5-13
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	8-13
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	14-15
Limitations	20	Discuss the limitations of the scoping review process.	15
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	15-16
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	16

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.

Estudo 3

sensors

MDPI

Article

Analysis of Older Adults in Spanish Care Facilities, Risk of Falling and Daily Activity Using Xiaomi Mi Band 2

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Abstract: Background: Presently the use of technological devices such as wearable devices has emerged. Physical activity monitoring with wearable sensors is an easy and non-intrusive approach to encourage preventive care for older adults. It may be useful to follow a continuous assessment of the risk of falling. The objective is to explore the relationship between the daily activity measured by Xiaomi Mi Band 2 and the risk of falling of older adults residing in or attending care facilities. Methods: A cross-sectional study was conducted on three different institutions located in Galicia (autonomous community) (Spain). Results: A total of 31 older adults were included in the study, with a mean age of 84 ± 8.71 years old. The main findings obtained were that a greater number of steps and distance could be related to a lower probability of falling, of dependency in basic activities of daily living, or of mobility problems. Conclusions: The importance of focusing on daily steps, intrinsically related to the objective assessment of daily physical activity, is that it is a modifiable factor that impacts different aspects of health and quality of life.

Keywords: daily steps; falls; health-related quality of life; nursing home; occupational therapy; physical activity; remote monitoring; sleep; wearable technology; wristband

check for updates

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1. Introduction

Currently, it is well documented that aging populations are progressively increasing. Older people represent 20.3% of the European population over 65 years old, after Japan with 28% [1,2]. Also, life expectancy increases, which means that people are expected to live longer, increasing the risk of chronic diseases and higher levels of dependency in daily life [3]. Therefore, as people age, they are more likely to need third-party support, which complicates the choice of aging in place and independently [4,5]. In this case, especially in Spain, there are three different options: living at home with home assistance either by a professional or by a nonprofessional carer, living at home and attending a day center, or going to a long-term care facility [6].

In Spain, and particularly in the Galicia autonomous community, older people represent 25.5% of the population, and the ratio of residential vacancies to 100 older people is around 3:1 [7]. The estimated number of older people living in Spain's nursing homes is 81.4% [8]. Usually, an older person who is institutionalized loses capacity and skills, which affects independence in daily life, presenting an imbalance in their occupational performance [9]. Likewise, they are more likely to have poor quality of life, low cognitive and physical status, affecting their daily lives [9].

During the aging process, chronic diseases can derive from a decreased physical activity level [10,11]. Over time, some studies have concluded that higher daily physical activity levels reduce chronic diseases in all age groups [12]. Thus, the World Health Organization (WHO) recommended adults aged 65 years get between 150 and 300 min of moderate-intensive physical activity per week [13].

The most inactive and active people in aging populations are at the highest risk of falls [14]. Thus, one of the most frequent syndromes in the older population is the risk of falling, which is the second leading cause of death worldwide and considered to be one of the most common reasons for a decreased level of physical activity and for institutionalizing older adults [14]. For this reason, falls are identified as an urgent global health challenge that, despite the pandemic situation, is gaining great importance, as well as indicating the importance of being physically active [15]. The incidence of falls in community-dwelling older people over 65 years is around 30%, and in residential care facilities, approximately 50% [14].

The risk of falling is associated with gait and balance problems, which also impact physical activity levels. Agmon et al. [16] demonstrated that the increased gait variability was a strong predictor of falls in older adults. Gait problems mean losing independence, a significant reduction in quality of life, increased risk of falling, and mortality and morbidity [16]. Some of the main fall factors are age, previous falls, living alone, use of medicines, gender, medical conditions (i.e., circulatory disease, depression, arthritis), impaired mobility and gait, sedentary behavior, fear of falling, nutritional deficiencies, impaired cognition, visual impairments, hearing loss, and foot problems [14].

People with a recent history of falls can acquire a fear of falling [14]. Occupational therapists have a key role in addressing the risk and fear of falling because it may limit a person's ability to engage in a meaningful occupation and lead to a sedentary lifestyle. As Wu et al. mentioned [16], occupational therapists may collaborate to manage the person's concerns about falling to maintain daily functions and independence [16]. Under these circumstances, new strategies and tools should be sought to assess aspects related to the risk of falling from an occupational perspective, for example, technological tool use. Furthermore, in a previous scoping review about the use of technology by occupational therapists in dealing with falls, there was not found any experience with wearable devices [17].

The existing literature is widely related to human activity detection for daily activities. It includes the detection of falls, the analysis of objective gait, the analysis of different signs and symptoms associated with neurological disorders (i.e., Parkinson's disease), among others [18]. Regarding fall detection, the solutions are focused on visual sensors, telecare solutions with user interaction, mobile applications, or wearable systems [19]. Wearables constitute any mobile device worn on the body, called on-body sensors, such as inertial measurement units, smart watches, wristbands, or Holter electrocardiogram monitors [20]. They provide objective and quantitative measures from controlled and unsupervised environments. As mentioned, they allow the development of accurate treatment plans and disease monitoring [21]. These objective techniques are body-fixed motion sensors, ranging from switches, pedometers, actometers, goniometers, accelerometers, and gyroscopes, mainly for physical activity assessment. Mechanical pedometers, known as step counters, are the basic wearable sensors to measure human motion. They are often used to compare data from the wristbands [22,23].

The analysis of using wearable technology has been developed in unsupervised environments under free-living conditions instead of in laboratories or clinical visits [20]. Wearable devices can track nearly everything, from providing early stroke detection to monitoring physiological parameters, quantifying physical activity, monitoring sleep quality, determining gait structures, and measuring plantar pressures and shear [24]. Also, the key advantage of wearable sensors is that no dedicated laboratory environment is needed to extract parameters of interest. Thus, mobility assessments, such as gait and balance tests, can be performed in any clinical setting and during a routine clinic visit [25]. In addition, monitoring people in a daily living environment and over continuous periods may become more feasible and ecological [20,26,27].

While using conventional geriatric assessment tools or questionnaires provides information on the purpose of the activity, wearable devices can quantify the motion performed. Both provide complementary information to the researchers, which are not interchangeable [28,29]. Likewise, as supported by Yang et al. [30], studies in fall risk assessment should recommend using wearable technologies to supplement nursing home assessment tools. In fact, at present, the use of technological devices such as wearable devices has been emerging. For instance, wearable sensors are an easy and non-intrusive approach to encourage preventive care for older adults. It may be useful to continuously monitor and assess daily activities in real-life environments [31].

Literature on the study topic has referred to the main wearable devices used in older adults' populations: wristbands, activity monitors, or accelerometers. The main objectives of using these devices are: (1) to explore the relationship between sleep behavior and gait performance [16], (2) to validate the devices by step count [32], (3) to evaluate the feasibility and efficacy of the device [33,34], (4) to determine the validity of a device compared to Actigraph [35,36], or (5) to understand the use of wristbands by older adults conducting qualitative or mixed studies [37–41].

The trusted wearable device with a research purpose is the Actigraph accelerometer (ActiLife, Pensacola, E.E.U.U.) [34]. Notwithstanding, Paul et al. determined that this accelerometer undercounts steps in older adults, especially in people with mobility impairments [32,35]. Furthermore, despite it being a budget option, DeGroote et al. [42]'s study reported a great agreement between the data from Actigraph and the Xiaomi Mi Band (Xiaomi, Beijing, China), which makes it a competent low-cost choice.

O'Brien et al. [33] supported that wristband activity trackers are an accepted method for recording daily physical activity among older adults. Previous studies have encouraged the use of the Xiaomi Mi Band, reporting that it seems to be one of the best packages for its price [43]. Also, Puri et al. [39]'s study showed that the Xiaomi Mi Band has an 80% acceptance by older adults, more than the Microsoft Band (50%), (Microsoft, E.E.U.U.). In this line, previous studies such as that of Mičková et al. [44], have used the Xiaomi Mi Band to assess physical activity, steps, and self-reported health in a group of older adults [44].

Tudor-Locke et al. [45] found that being physically active is associated with higher levels of functional health, lower risk of falling, and improved cognitive health.

Accordingly, this study aims to examine the association between Xiaomi Mi Band 2 parameters, especially for daily steps, with older adults who are at risk of falling, residing, or attending a care facility. This study aims to describe their fall history and determine the influence of daily steps and sleep on dependency in basic activities of daily living (B.A.D.L.), having a cognitive impairment, and having any problem associated with health-related quality of life (HRQoL). Finally, this study aims to analyze the utility of the Xiaomi Mi Band 2 to assess older adults' daily activity and sleep.

2. Materials and Methods

2.1. Study Design

An observational descriptive cross-sectional study was conducted on three different institutions located in Galicia autonomous community (Spain), all of them providing services as a residence and day center. It is part of the GeriaTIC project [46] (Clinical Trials NCT03504813), in which two institutions participated, and another project (Clinical Trials NCT04592796), in which one institution participated. The three institutions have similar characteristics and similar populations. The study began in March 2017, and it was completed in December 2019.

2.2. Participants

A purposive sampling was used to recruit the participants from the three institutions. They were eligible for study entry if they met the following criteria:

- aged over 65 years old;
- resided in or attended a nursing home or day center;

- able to walk 3 m;
- able to provide written informed consent;
- understood, spoke, and read Spanish proficiently;
- not having requested a transfer to another center;
- agreed to wear the wristband for 30 days (during the day and night).

2.3. Data Collection

The participants had to wear the Xiaomi Mi Band for 30 days, 24 h a day. The assessment tools selected were administrated the first day of wristband use to draw a baseline about the sample. A data set about the variables was compiled [47].

2.4. Tools and Measures

2.4.1. Institution Database

The variables selected were sex (male or female), age, care facility (nursing home or day center), marital status (widow or not), body mass index (normal weight or overweight), and the number of diagnoses from the medical record.

The diagnoses most closely related to the risk of falling were selected and classified into the following groups:

- Diagnoses of any of these physical conditions: osteoporosis, osteoarthritis, dizziness and giddiness, rheumatoid arthritis, abnormalities of gait and mobility, or multiple sclerosis.
- Diagnoses of any of these cognitive conditions: Alzheimer's disease, dementia, or age-associated cognitive decline.
- Diagnoses of other health conditions: hypertension, visual impairment, diabetes, or hearing loss.

Other variables included were the number of certain assistive aids used (glasses, hearing aid, or anti-decubitus pillow), the number of mobility aids (cane or walker), the number of falls in the last 12 months, and fall classification profile (non-fallers with any fall in the last 12 months, or faller with one or more falls in the last 12 months) [30].

In addition, the institution database obtained the most recent Barthel Index Score, Tinetti Index Score, and the presence or not of cognitive impairment. Barthel Index measures the level of dependency in B.A.D.L. such as feeding, bathing, grooming, dressing, bowel control, bladder control, toilet use, transfers, mobility on level surfaces, and up and downstairs. In the Barthel Index the score ranges between 0 and 100 points, 100 is considered independency in B.A.D.L., and >100 is considered any level of dependency in B.A.D.L. [48]. The Tinetti Scale assesses the risk of falling based on gait and balance, and the total score is between 0 and 28, considering $\geq$24 as no risk of falling and <24 as the risk of falling [49].

2.4.2. Health-Related Quality of Life

The EuroQol-5D-5L (EQ-5D-5L) was used to explore the perception of each participant about their HRQoL. It evaluates four elements [50]. The first element consists of a descriptive system of five dimensions: mobility (walking ability), self-care (washing or dressing), usual activities (i.e., work, study, household chores, family activities, or leisure time activities), pain/discomfort, and anxiety/depression; these are assessed as: (1) no problems, (2) slight problems, (3) moderate problems, (4) severe problems, or (5) extreme problems/inability. In this case, we considered those having any problem or no problem to analyze [50]. The second element was a Visual Analog Scale (VAS), in which the person rates his/her perceived health from 0 (the worst imaginable health) to 100 (the best imaginable health) [50]. Finally, the third and fourth elements (the EQ-5D-5L Index and the Severity Index, respectively) are two indexes calculated from the descriptive system's scores. The EQ-5D-5L Severity Index score between 0 (absence of problems) to 100 (more severity), and the EQ-5D-5L Index between 0 (state of health similar to death) and 1 (better health status) [50].

2.4.3. Xiaomi Mi Band 2

The participants were monitored for 30 days with the Xiaomi Mi Band 2 located on their dominant hand. This band has a battery of about 30 days, so it was unnecessary to load during the study period. This device was used to count steps in order to provide a means of objectively quantifying total daily activity. Individual Gmail accounts were created for each participant to collect the data from the wristbands, and through the Mi Fit mobile application, the data were extracted to an Excel document. The parameters obtained were the 30-day averages based on the following variables:

- Daily activity: analyzed through the number of daily steps and the daily distance covered by each participant in meters. Based on Tudor-Locke's study, <3000 steps indicated a low level of physical activity and 3000–10,000 steps indicated a moderate physical activity level [23].
- Sleep: analyzed in minutes in four different parameters (daily deep sleep, daily shallow sleep, total daily sleep, and awake time in bed during the night). The Sleep Foundation recommendation was used to reference older adults' adequate sleep of around 7–8 h, which corresponds to 420–480 min per day [51].

Data from the wristbands were compared by the institution's professionals, and the researchers asked the participants weekly about their sleep and daily activity to ensure that the data represented their daily lives. Likewise, if the Mi Fit mobile application showed null values, this meant that the person had not worn the wristband or even that the device was failing. In this study, the institution's professionals supervised if the participant wore the wristband daily.

2.5. Statistical Analysis

Statistical analyses were conducted using International Business Machines Corporation (I.B.M.®) Statistical Package for the Social Sciences (S.P.S.S.®) version 25. First, descriptive analysis was done using the data as means and standard deviation or frequencies and percentages, as appropriate.

Concerning inferential analysis, in the case of two categorical variables, the chi square test was implemented, contrasted with the Fisher test, since more than 20% of the boxes had values lower than 5. For these reasons, the categorical variables were grouped into two different values to create 2 × 2 contingency tables. The effect size was checked with Cramer's V, which has values between 0 and 1, so values close to 1 indicated a strong association.

On the other hand, the normality of the numerical variables was analyzed with the Shapiro–Wilk test, which is intended for small samples. Variables with a normal distribution (Shapiro–Wilk test with $p > 0.05$) were analyzed with Student's T test (tested in each categorical variable) and Pearson Correlation (correlation with other numerical variables), and those with abnormal distribution (Shapiro–Wilk test with $p < 0.05$) were analyzed with the Spearman correlation test (correlation with other numerical variables) and Mann–Whitney U test (numerical variables with abnormal distribution and categorical variables). Spearman and Pearson coefficient "rho" (values from 0 to 1) determined the correlation's magnitude, and for Mann–Whitney U test results, GPower 3.1. software was used to calculate the effect size (the estimated magnitude of the relationship) and the statistical power (the probability that the null hypothesis was accepted when the alternative hypothesis was true) of the correlations and associations according to Hedges' g, which was indicated with "g" and the statistical power indicated with "β". Then g values below 0.2 indicated a small effect size, 0.5 of medium magnitude, and 0.8 indicated a high magnitude effect.

Regarding the significant associations previously explored, associations of risk of falling and Xiaomi Mi Band 2 parameters were analyzed using simple binary regressions, which were implemented to determine Odds Ratios (ORs) since the dependent variables are categorical and take two values (0, 1). The values of Cox and Snell R^2 and Nagelkerke R^2 indicate the percentage by which the regression explains the relationship between the variables. When the value is greater than 0.4, 40% of the regression explains the association between the variables. It can be considered a good result.

Lastly, the authors decided to apply a generalized model developed with Gamma distribution and logarithm link. This type of model is used for variables that do not have a normal distribution and have an integer and positive values, as in daily steps [52].

2.6. Ethical Concerns

The present study followed the ethical concerns of the Declaration of Helsinki for human research ethics. Moreover, participant confidentiality was ensured under Regulation 2016/679 and repealing Directive 95/46/E.C. of the European parliament to protect personal data. Participants received complete verbal and written information about the characteristics of the study and the implications derived from their participation in it. Once it was ensured that all participants fully understood the information provided, they agreed to participate in the study through the Informed Consent Document. The data of the participants were collected and preserved until the end of the study in coded mode.

3. Results

A total of 31 older adults were included in the study. As reported in Table 1, the mean age was about 84 years old. There was also homogeneity in gender, in which women represented 51.6% of the sample. Members of this sample mainly resided in a nursing home (n = 28) and were widows (83.9%), overweight (71%), had problems associated with any physical condition (54.8%) (i.e., osteoporosis, osteoarthritis, dizziness, and giddiness, rheumatoid arthritis, abnormalities of gait and mobility, or multiple sclerosis), with the presence of cognitive impairment (64.35%), with any level of dependency in B.A.D.L. (77.4%), took fewer than 3000 steps per day (87.1%), slept less than 420–480 min per day (54.83%), and used mobility aids (41.9%). Likewise, during the study, if any participant suffered a fall, this variable was not analyzed.

Table 1. Sample main characteristics.

Characteristic	N (%)/Mean (±SD)
Age	84 (±8.71)
Women	16 (51.6%)
Residing in a nursing home	28 (90.3%)
Widow	28 (83.9%)
Overweight	22 (71%)
Problems of physical conditions	17 (54.8%)
Cognitive impairment	20 (64.5%)
Dependency in basic daily activities	24 (77.4%)
Risk of falling	21 (67.7%)
Take fewer than 3000 daily steps	27 (87.1%)
Sleep less than 420–480 daily minutes	17 (54.83%)
Use of mobility aids	13 (41.9%)
EQ-5D-5L VAS > 50	26 (12.9%)

3.1. History of Falls

The history of falls expresses the number of falls experienced in the last 12 months before the present study. Figure 1 reports the distribution of falls and their main reasons. According to this, 45.2% of the sample (n = 14) had falls in the last 12 months. The total amount of falls was 25, and 32% of them had not identified the reason in the institutional database. Most of the falls happened when the person was alone (n = 22) and when he or she was in a room of the care institute (n = 21).

An analysis of the possible association between having a previous fall and the risk of falling was implemented. However, there was not found a significant association ($p > 0.05$). It should be noted that 11 of the 15 participants who had one or more previous falls were at risk of falling.

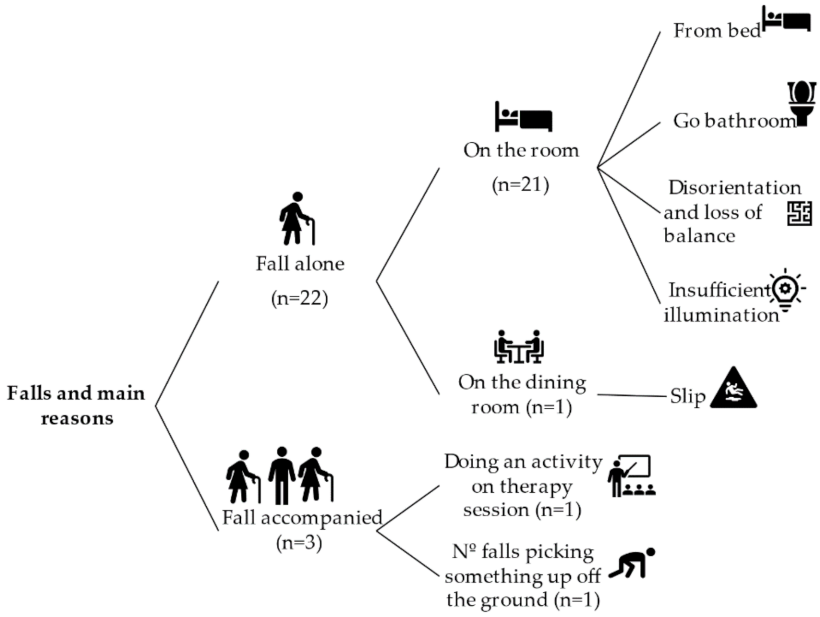

Figure 1. Fall distribution and main causes.

3.2. Risk of Falling

We investigated the risk of falling. We determined that the risk of falling may be associated with having any level of dependency in B.A.D.L. (p = 0.002, V = 0.618), taking fewer than 3000 steps per day (p = 0.007, V = 0.618), having four or more diagnoses (p = 0.006, V = 0.539), using mobility aids (p = 0.006, V = 0.532), having any physical condition (p = 0.018, V = 0.483), and using a walker (p = 0.03, V = 0.441).

Regarding the problems identified in the five dimensions of the EQ-5D-5L descriptive system, we found a positive and moderate association with mobility problems (p = 0.015, V = 0.585). However, there were identified negative strong associations with problems in self-care (p = 0.002, V = −0.483) and moderate association with problems in usual activities (p = 0.018, V = –0.483). No association between risk of falling and pain and discomfort or anxiety or depression was determined.

Moreover, we found associations between risk of falling and the number of diagnoses (F = 8, p = 0.007), the number of mobility aids used (F = 10, p = 0.003), the Barthel Index Score (F = 16, p > 0.001), the EQ-5D-5L Severity Index (F = 5.3, p = 0.028), and the EQ-5D-5L Index (F = 5.3, p = 0.028).

3.3. Health-Related Quality of Life

Related to HRQoL, the sample represented, as reported in Table 2, an EQ-5D-5L VAS of about 69 ± 15, EQ-5D-5L Index of about 0.68 ± 0.25, EQ-5D-5L Severity Index of about 22 ± 18, and a score greater than 50 in EQ-5D-5L VAS in 87.1% of the participants.

Table 2. EQ-5D-5L scores.

	EQ-5D-5L VAS	EQ-5D-5L Index	EQ-5D-5L Severity Index
Mean	69	0.68	22
Standard deviation	±15	±0.25	±18
Minimum	40	0.03	0
Maximum	100	1	65

Figure 2 reports the percentage of problems identified by the participants on each EQ-5D-5L descriptive system dimension. It should be noted that not identifying problems or identifying slight problems in mobility, self-care, usual activities, pain and discomfort, and anxiety and/or depression predominated.

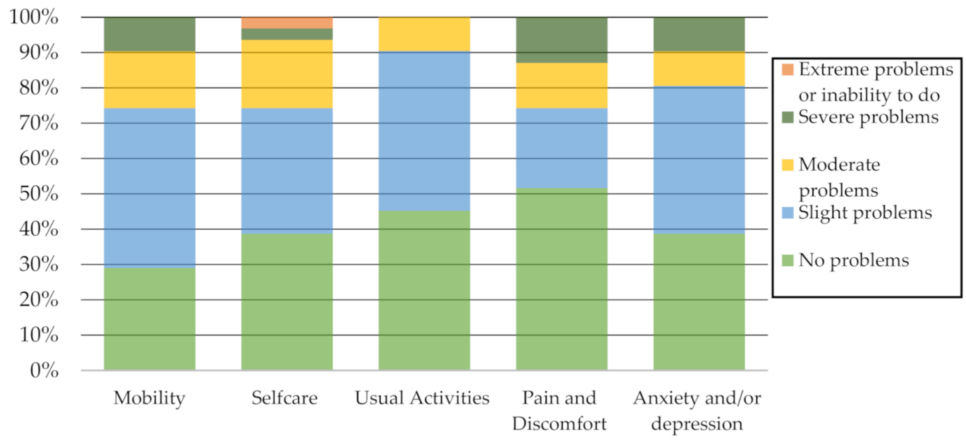

Figure 2. EQ-5D-5L Descriptive system dimensions.

3.4. Xiaomi Mi Band 2 Parameter Associations

The Student's T test and Mann–Whitney U test were used to explore the association between the parameters measured by the Xiaomi Mi Band 2, which were the independent variables (daily steps, daily distance covered, daily deep sleep, daily shallow sleep, and daily awake time at night), with being or not being at risk of falling, the presence or not of any level of dependency in B.A.D.L., and the presence or not of cognitive impairment, which were the dependent variables (see Table 3).

Table 3. Xiaomi Mi Band 2 parameter associations.

Dependent Variables	Independent Variables					
	Daily Steps	**Daily Distance**	**Daily Deep Sleep**	**Daily Shallow Sleep**	**Daily Total Sleep**	**Daily Awake Time at Night**
Risk of falling	a **	a **	a	a	a	a *
Yes	720 (±480)	446 (±61)	150 (±67)	271 (±93)	360 (±118)	56 (±44)
No	3366 (±2139)	2161 (±477)	174 (±20)	303 (±83)	421 (±85)	19 (±11)
Level of dependency in B.A.D.L.	b ***	b **	b **	a	a	a
Yes	696 (2593)	449 (1651)	164 (180)	285 (385)	360 (533)	151 (17)
No	4509 (7213)	3008 (4817)	180 (149)	303 (252)	446 (141)	17 (41)
Cognitive impairment	a	a	b	b	b	a
Yes	1915 (±2048)	1232 (±1381)	174 (264)	308 (278)	390 (209)	46 (±42)
No	953 (±834)	569 (±507)	102 (186)	261 (385)	363 (533)	42 (±39)

[a] Student's T test shown with Mean (Standard Deviation). [b] Mann–Whitney U Test shown Median (Range). *p*-value > 0.05 *, *p*-value > 0.01 **, *p*-value > 0.001 ***. The effect size was in contrast with Hedges' g.

With the risk of falling, there were strong associations of daily steps ($p < 0.001$, F = 27), daily distance covered ($p < 0.001$, F = 31), and weak association with daily awake time at night ($p = 0.013$, F = 0.127).

The strongest associations with dependency in B.A.D.L. were with daily steps ($p < 0.001$, g = −2.086, β = 0.99), daily distance covered ($p = 0.005$, g = −2.666, β = 0.99) and daily deep sleep ($p = 0.005$, g = −0.793, β = 0.54). However, no significant associations were found with cognitive impairment.

Related to the EQ-5D-5L descriptive dimensions, which were the independent variables, (see Table 4), strong associations were found with daily steps and mobility ($p = 0.001$, g = −1.432, β = 0.97), self-care ($p > 0.001$, g = 1.404, β = 0.97), and usual activities ($p < 0.001$, g = 0.956, β = 0.76), and a moderate association with pain and discomfort ($p = 0.008$, g = 0.860, β = 0.68), as well as similar associations were found with daily distance covered.

Table 4. Associations between descriptive dimensions of EQ-5D-5L and Xiaomi Mi Band 2 parameters.

Dependent Variables	Independent Variables					
	Daily Steps	Daily Distance Covered	Daily Deep Sleep	Daily Shallow Sleep	Daily Total Sleep	Daily Awake Time at Night
Mobility	b **	b **	a	a **	a	b
Any problem	683 (4363)	435 (2927)	147 (±68)	255 (±91)	354 (±117)	27 (151)
No problem	2503 (7256)	1654 (4849)	183 (±57)	345 (±43)	440 (±67)	22 (102)
Self-care	b ***	b ***	a	a	a	b
Any Problem	2339 (7256)	1543 (4849)	174 (±59)	317 (±61)	424 (±67)	19 (105)
No problem	519 (1774)	316 (980)	147 (±70)	258 (±98)	351 (±125)	27 (151)
Usual activities	a *	a *	b	b	b *	a
Any Problem	2435 (±2095)	1534 (±1442)	169 (247)	308 (224)	420 (307)	159 (±71)
No problem	864 (±1036)	558 (±691)	173 (226)	252 (385)	360 (533)	157 (±64)
Pain and discomfort	b **	b **	b	b **	b *	a
Any problem	1263 (7500)	799 (5021)	176 (264)	326 (215)	420 (294)	43 (±41)
No problem	661 (1774)	433 (914)	160 (209)	248 (385)	360 (533)	46 (±41)
Anxiety and/or depression	b	b	a	b	a	b
Any problem	830 (4834)	513 (3256)	159 (±59)	312 (346)	389 (±120)	24 (121)
No problem	751 (7796)	462 (5224)	157 (±72)	281 (282)	378 (±108)	27 (150)

[a] Student T test shown with "Mean (Standard Deviation)". [b] Mann–Whitney U Test shown in the boxes with "Median (Range)". *p*-value > 0.05 *, *p*-value > 0.01 **, *p*-value > 0.001 ***. The effect size was in contrast with Hedges' g.

It was concluded that with a higher number of daily steps and daily distance covered, fewer problems were identified in mobility and more problems were identified with pain and discomfort. Moreover, we found a moderate association between daily shallow sleep and mobility (p = 0.005, F = 3.78), and with pain and discomfort (p = 0.003, g = 1.066, β = 0.84). Daily total sleep was associated with usual activities (p = 0.042, g = 0.654, β = 0.53) and a low association with pain and discomfort (p = 0.02, g = −0.071, β = 0.07). No associations were encountered with daily deep and daily awake time with the dimensions of the EQ-5D-5L descriptive system.

3.5. Correlations and Associations with Daily Steps

Daily steps had no relation with age, gender, and body mass index ($p > 0.05$). However, after the implementation of the Pearson Correlation (normal distribution) and Spearman Correlation (abnormal distribution), we identified other correlations. This analysis determined that the significant, strongest, and positive correlations with daily steps were with Barthel Index Score ($p < 0.001$, rho = 0.691), EQ-5D-5L Index Score ($p < 0.001$, rho = 0.603), and EQ-5D-5L VAS (p = 0.013, rho = 0.377). The negative strongest correlations with daily steps were the number of mobility life aids used ($p < 0.001$, rho = −0.625), EQ-5D-5L Severity Index Score ($p < 0.001$, rho = −0.564, β = 0.99), daily awake time at night ($p < 0.01$, rho = −0.506), number of diagnoses ($p < 0.01$, rho = −0.462), number of assistive aids ($p < 0.05$, rho = −0.367). We did not find correlation with age (p = 0.155, rho = −0.262) and Tinetti Score ($p > 0.050$, rho = −0.063).

3.6. Risk of Falling Binary Regression

Concerning the risk of falling, a binary regression model was carried out, obtaining a Cox and Snell R^2 of 0.408 and a Nagelkerke R^2 of 0.571, which could be considered a good fit model. The following variables were removed from the model because they did not have a predictive effect on the risk of falling: taking fewer than 3000 steps per day, physical conditions, mobility aids, problems in self-care, and problems in mobility. Thus, the final model suggested that a person at risk of falling was 24 times more likely to present any level of dependence ($p = 0.016$, OR = 24) and 11 times more likely to have four or more diagnoses ($p = 0.038$; OR = 11).

3.7. Xiaomi Mi Band 2 Parameters Binary Regressions

Binary regressions (see Table 5) were performed according to the significant associations reported in Tables 3 and 4.

Table 5. Binary regression of Xiaomi Mi Band parameters.

Dependent Variable	Independent Variable	OR 95% CI	Cox and Snell R^2	Nagelkerke R^2
No risk of falling	Daily steps	1.004 (1.001–1.008) *	0.570	0.796
	Daily distance covered	1.006 (1.001–1.011) *	0.534	0.746
	Daily awake time at night	0.913 (0.843–0.989) *	0.346	0.483
Independency on B.A.D.L.	Daily steps	1.001 (1.000–1.003) *	0.375	0.571
	Distance daily covered	1.002 (1.000–1.004) *	0.388	0.591
	Daily deep sleep	1.014 (0.995–1.033)	0.124	0.189
EQ-5D-5L Mobility dimension–no problems	Daily steps	1.085 (0.926–1.272) **	0.411	0.587
	Daily distance covered	1.002 (1.001–1.004) **	0.420	0.599
	Daily shallow sleep	1.024 (1.003–1.045) *	0.334	0.477
EQ-5D-5L Self-care dimension–no problems	Daily steps	0.998 (0.996–1.000) *	0.424	0.576
	Daily distance covered	1.088 (0.811–1.460) *	0.453	0.615
EQ-5D-5L Usual activities dimension–no problems	Daily steps	0.999 (0.998–1.000) *	0.261	0.349
	Daily distance covered	0.999 (0.997–1.000)	0.233	0.312
	Daily total sleep	0.994 (0.985–1.003)	0.106	0.142
EQ-5D-5L Pain and Discomfort dimension–no problems	Daily steps	0.999 (0.997–1.000)	0.321	0.428
	Daily distance covered	0.998 (0.995–1.000)	0.352	0.469
	Daily shallow sleep	0.986 (0.974–0.999) *	0.303	0.404
	Daily total sleep	0.993 (0.983–1.003)	0.225	0.300

OR = Odds Ratio, CI = confidence interval. Adjusted by sex, age, and body mass index. * $p < 0.05$; ** $p < 0.01$.

Regarding the binary regressions, higher level of daily steps had an association with more probabilities of not having a risk of falling ($p < 0.05$, OR = 1.004, R^2 = 0.570–0.796), perceiving no problems in EQ-5D-5L Mobility ($p < 0.01$, OR = 1.085, R^2 = 0.411–0.587), perceiving no problems in EQ-5D-5L Usual activities ($p < 0.05$, OR = 0.999, R^2 = 0.261–0.349), not having a dependency in B.A.D.L. ($p < 0.05$, OR = 0.913, R^2 = 0.375–0.571), and having a minor probability of not perceiving problems in EQ-5D-5L Self-care ($p < 0.05$, OR = 0.998, R^2 = 0.424–0.576).

Related to the other Xiaomi Mi Band 2 parameters we observed that greater daily distance covered was associated with greater probability of not having a risk of falling ($p < 0.05$, OR = 1.006, R^2 = 0.534–0.746), greater probability of not having a level of dependency in B.A.D.L. ($p < 0.05$, OR = 1.002, R^2 = 0.388–0.591), greater probability of not having perceived problems in EQ-5D-5L Mobility ($p < 0.01$, OR = 1.002, R^2 = 0.420–0.599) and having a minor probability of not having problems in EQ-5D-5L Self-care ($p < 0.05$, OR = 0.998, R^2 = 0.453–0.615). Daily awake time at night was associated with a minor probability of not having a risk of falling ($p < 0.05$, OR = 0.913, R^2 = 0.346–0.483). Moreover, daily shallow sleep was associated with not having perceived problems in EQ-5D-5L Mobility ($p < 0.05$, OR = 1.024, R^2 = 0.334–0.477) and a minor probability of not having perceived problems in EQ-5D-5L Pain and Discomfort ($p < 0.05$, OR = 0.986, R^2 = 0.303–0.404).

3.8. Generalized Model of Daily Steps

A generalized model was applied with a distribution of Gamma and Logarithm link function. The dependent variable was daily steps with the stronger correlations and associations that were previously found.

Results from the generalized model are reported in Table 6. Many of the variables with significant association or correlation were removed due to not being significant predictors. Finally, we obtained that daily steps had a negative association with the risk of falling ($p < 0.001$, OR = 0.312) and when a person had any level of dependence in basic daily activities ($p = 0.27$, OR = 0.567). It meant that a person had 0.312 times higher risk of falling or 0.567 times higher dependency on basic activities when taking fewer steps per day, which meant that the more steps you take each day, the more likely you are to not be at risk of falling or becoming dependent; specifically, a person is about twice likely to not be at risk of falling or becoming dependent if he/she has an adequate level of daily steps.

Table 6. Generalized model of daily steps.

Predictor	OR 95% CI
Risk of falling	0.312 (0.161–0.568) ***
Any level of dependence on basic daily activities	0.567 (0.281–1.150) *

* $p < 0.05$; *** $p < 0.001$.

The associations between daily steps and the level of dependency in B.A.D.L. and risk of falling are shown in Figure 3.

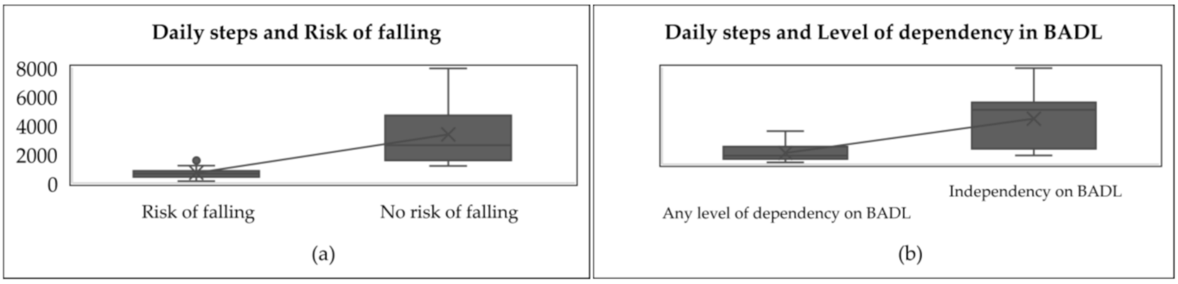

Figure 3. Associations between daily steps and level of dependency in B.A.D.L. and risk of falling. (**a**) it is shown the comparison of daily steps between people with risk of falling and people with no risk of falling. (**b**) it is shown the comparison of daily steps between dependent people and independent people.

Figure 3 shows that people at risk of falling took fewer steps per day (between 146 and 1920) in comparison to people with no risk of falling, who took more steps per day (between 1188 and 7942). In other words, the average number of steps taken by the people with a risk of falling was lower (937 $\pm$ 738), while those taken by people with no risk of falling was greater (3755 $\pm$ 2527). Likewise, dependent people took fewer steps per day (between 146 and 2739) compared to independent people, who took more steps per day (between 729 and 7942). By comparing both in Figure 3, it is shown that dependent people's steps mean per day was lower (937 $\pm$ 738) while independent people's steps mean per day was greater (3755 $\pm$ 2527).

4. Discussion

The present study examined the Xiaomi Mi Band 2 parameters and older adults' health related to physical activity and risk of falling. The main findings obtained were that a greater number of steps and distance could suppose a lower probability of presenting a risk of falling, dependency in B.A.D.L., or perception of mobility problems. In this way, as Patterson's study [53] concluded, there is no agreement on what dose of physical activity should be performed to maintain a person's functional independence. However, it is known that with moderate physical activity levels, there can be significant results [53]. Likewise, the relationship between staying physically active and engaging in regular physical activity, with health benefits, particularly in fall rate reduction has been well documented for decades [54].

The number of steps taken by the participants who did not perceive mobility problems, were not at a risk of falling, and were independent in B.A.D.L. were between 2503 median steps in a range of 7256, a mean of 3366 steps ± 2139, and a median of 4509 in a range of 7213, respectively. In other words, considering these three aspects, the number of daily steps ranged from 2500 to 6000 steps approximately. Similar data were obtained in the O'Brien study, in which the intermediate steps of older adults were 2500–4000 [33]. However, according to Tudor-Locke et al. [45], this range fits a sedentary profile. These authors suggested that below 6000 daily steps could not provide health benefits [45]. It suggests that physical activity levels should be increased, although it should be noted that the mean age of the participants was 84 ± 8.71 years old, with 87.1% of the participants who took fewer than 3000 steps per day. Thus, it is not clear whether this level of physical activity may significantly affect their health for this population.

Daily steps are a modifiable factor intrinsically related to the objective assessment of daily physical activity. They have a strong impact on health in any population, but especially in older adults. It affects their level of independence and quality of life, taking into account the repercussions of falls [55]. This study suggested that wearable devices, like Xiaomi Mi Band 2, may be used for appropriate assessments, which can help to identify those with an increased risk of falls to reduce the negative impact of falls in older adults [56]. A total of 45.2% of the sample had previous falls, considering that their normal incidence in nursing homes is 50% [14]. Despite the pandemic situation, falls are still gaining great importance [15], making them a focus of attention. In this case, health professionals and caregivers played a central role in mitigating unnecessary risk-taking [57].

The association between having a previous fall and the risk of falling was investigated. Nevertheless, no association was found. However, previous studies have indicated that older fallers have a high prevalence of fall risk factors and are at risk of functional decline [58]. As aforementioned, it was possible to observe a lower risk of falling at a higher level of physical activity.

Regarding sleep, in this study, we observed that daily awake time at night was weakly associated with the risk of falling ($p = 0.013$, F = 0.127). Although the data were not supported by strong associations and knowing that it is necessary to consider the quality of sleep as measured by deep sleep, shallow sleep, and total sleep, they showed an important aspect of using wearables devices. Wearable devices continuously monitor the person, which provides the approximate time that the person has been awake at night, and, therefore, they can help to understand their needs.

In this way, Stefan et al. [59] reported that older adults with short sleep duration are less likely to meet physical activity guidelines. In contrast, those who report long sleep duration and good sleep quality are more likely to meet physical activity guidelines [59]. In the present study, the participants who perceived problems with mobility were likely to have more daily shallow sleep. In contrast, people with perceived pain and discomfort problems had a higher risk of getting less daily shallow sleep. In other words, we found that people with subjective pain and discomfort may get less shallow sleep. However, it should be compared with deep sleep to examine the quality of sleep, but in this case, no significant associations were found to conclude. Similarly, no significant relations were found with cognitive impairment, and perceived problems with usual activities, or total sleep parameters and deep sleep.

The existing literature has supported a relationship between short sleep duration and injury from falling [54]. In addition, maintaining daily routines was associated with a reduced rate of insomnia in older adults [60]. In the present study, 54.83% of the participants slept less than 420–480 min, which is the adequate range of sleep per day [51], while participants with a risk of falling slept 360 ± 118 min per day in comparison with those with no risk of falling, who slept 421 ± 85 min per day. It means that people who are not at risk of falling, sleep more, and have sleep levels that are within the appropriate range, although it was not possible to conclude a significant relationship.

Regarding the risk of falling, we found that a person at risk of falling is 24 times more likely to present any level of dependence and 11 times more likely to have four or more diagnoses following the risk factors collected by the WHO, who specified different medical conditions, mobility and gait impaired, and sedentary behavior, among others [14]. Thus, the risk of falling may be related to dependency and comorbidity. The association with the use of mobility aids has not been established, which may affect the number of daily steps. Also, it has not been possible to determine whether these aids can be a facilitator or a barrier in older adults' daily lives.

4.1. Limitations

The main limitations identified are the size and heterogeneity of the sample, since they influenced our being able to draw strong conclusions or associations between some aspects of physical activity and the risk of falling. Other risk factors for falls, such as fear of falling, medication, nutrition, or environmental adaptation, should be considered.

4.2. Further Work in the Field

It would be important to carry out a case-control study with an appropriate sample size to determine whether having a risk of falling influences the number of daily steps taken, as this study suggests that people who are not at risk of falling could take more steps per day. Also, further studies should include other variables such as fear of falling, medication, nutrition, or environmental adaptation, to explore how they influence the risk of falling.

4.3. Clinical Implications

Wearable devices can make older people aware of their physical activity and sleep. As Hopman reported, physical activity promotion is a difficult challenge to the habits of older adults [61]. In this way, as mentioned above, occupational therapists have a key role in promoting healthy routines and habits. In addition, any health professional and caregiver play a central role in mitigating unnecessary risk-taking [57]. Thus, an interdisciplinary team is necessary to address the risk of falling. Carers should receive the necessary training from occupational therapists or other health providers to prevent or reduce falls.

Wristbands may be an effective and fast way to evaluate people without requiring extended time for professionals to determine their day-to-day needs. It will now be useful in the COVID situation to observe how this situation has affected people's physical activity and sleep levels.

5. Conclusions

The main findings obtained were that a greater number of steps and distance could be related to a lower probability of presenting a risk of falling, dependency in B.A.D.L., or perception of mobility problems.

Based on the results, cognitive impairment does not have strong associations with any of the Xiaomi Mi Band 2 parameters selected (steps, distance, deep sleep, shallows sleep, total sleep, and awake time at night).

Regarding sleep, the results suggest that people at risk of falling tend to be awake longer at night, independent people get more deep sleep, people who identify problems in their usual activities have a lower total sleep time, and finally, people who identify pain or discomfort have less light sleep and sleep in total.

The risk of falling may be related to dependency and comorbidity. However, we cannot determine whether mobility aids can be a facilitator or a barrier in older adults' daily lives.

Lastly, wearable devices continuously monitor the person, which can help to understand their needs. The importance of focusing on daily steps, intrinsically related to the objective assessment of daily physical activity, is because it is a modifiable factor that impacts different aspects of health, quality of life, and risk of falling.

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