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The potential health and economic impact of gym usage in Belgium

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Voorwoord - Préface - Preface

Prof. Lieven Annemans

Nederlands

De jongste jaren wint het begrip positieve gezondheid aan belang. Het betekent dat iemands gezondheid niet perfect hoeft te zijn maar dat die gezondheid toelaat te kunnen functioneren en deel te nemen aan de samenleving. En dat heeft baten zowel voor de persoon in kwestie als voor de samenleving. Het samengaan van fysieke en geestelijke gezondheid wordt daarbij ook steeds meer benadrukt. En lichaamsbeweging heeft op beide een gunstig effect, via het verminderen van de kans op ziekten die zowel het lichaam als de geest aantasten en via een onmiddellijk effect op de kwaliteit van leven. Lichaamsbeweging zorgt bovendien ook vaak tot meer verbinding tussen mensen.

In dit rapport tonen we de resultaten van wat regelmatige en begeleide lichaamsbeweging betekent voor de mensen zelf en voor de samenleving. Voor velen zal de omvang van die impact verrassend zijn. De resultaten wijzen er ook op dat in omstandigheden van een pandemie zoals we meemaken de beleidskeuzes gebaseerd moeten worden op een brede visie en rekening moeten houden met alle gevolgen van die keuzes op fysiek, psychisch en sociaal vlak. Hopelijk zal het rapport dan ook de aandacht krijgen die het verdient en zal het iedereen aanzetten tot denken en beleidsmakers tot actie.

Français

Ces dernières années, le concept de santé positive a gagné en importance. Il consiste à dire que la santé d'une personne ne doit pas être parfaite, mais qu'elle doit lui permettre de fonctionner et de participer à la société. Et cette santé positive est bénéfique, tant pour la personne concernée que pour la société. Le lien entre santé physique et santé mentale est de plus en plus mis en avant. Et l'activité physique a un effet positif sur les deux, car elle réduit le risque de maladies qui affectent le corps et l'esprit, et elle a un impact immédiat sur la qualité de vie. En outre, l'activité physique tend également à renforcer le contact entre les personnes.

Dans ce rapport, nous montrons ce qu’une activité physique régulière et encadrée signifie pour les personnes elles-mêmes et pour la société. Pour beaucoup, l'ampleur de cet impact sera surprenante. Les résultats indiquent également que dans les circonstances d'une pandémie telle que nous la vivons aujourd’hui, les choix politiques doivent être fondés sur une vision large et tenir compte de toutes les conséquences de ces choix sur le plan physique, psychologique et sociétal. Espérons donc que le rapport recevra l'attention qu'il mérite et qu'il incitera chacun à réfléchir et les décideurs à agir.

English

In recent years the concept of positive health has become an increasingly important one. Positive health means that a person does not have to be in perfect health, just that their health allows them to function and be a part of society. This approach benefits both the person in question and society as a whole.

The relationship between physical and mental health is an associated aspect that has also gained ground, with physical exercise aiding both, given that it reduces the chance of physical and mental diseases and has an instant impact upon quality of life. Furthermore, physical exercise frequently also brings people closer together.

In this report we demonstrate what regular and monitored physical exercise means to the individual and to society. The extent of that impact will be surprising to many readers. Meanwhile, the results also show that, in the face of a pandemic like the one we are currently dealing with, policy decisions must be based on a wide perspective and must take into account the physical, psychological, and social consequences. We consequently hope that this report will receive the attention it deserves, will be thought-provoking, and will also encourage policymakers to act.

Dir. Eric Vandenabeele

Nederlands

Fitness.be, de Belgische beroepsvereniging voor de fitnessindustrie is, samen met alle stakeholders uit haar sector, al jaren protagonist omtrent de promotie van een gezonde leefstijl. Regelmatig en gecontroleerd bewegen, zoals aangeboden binnen fitnessclubs, maakt daar een essentieel deel van uit. Beoefenaars krijgen meer weerbaarheid, immuniteit, fysiek en mentaal welzijn. Mensen hier naartoe begeleiden is de kerntaak van fitness professionals. Tijdens de coronacrisis gingen experten en politici op zoek naar methoden om burgers maximaal te beschermen.

We moeten echter vaststellen dat er heel weinig aandacht ging naar preventieve gezondheidszorg via de promotie van een gezonde leefstijl. Nochtans was van bij aanvang duidelijk dat dit, net zoals het een buffer is tegen verschillende leefstijl gerelateerde aandoeningen, zorgde voor meer weerbaarheid tegen Covid-19.

Politici laten zich terecht leiden door advies gesteund op wetenschappelijk onderzoek. Als beroepsvereniging vonden we het dan ook belangrijk om binnen deze problematiek onze maatschappelijke rol op te nemen en duidelijkheid te scheppen omtrent de argumenten aangehaald door onze professionals. Zowel bij de VUB als bij HICT hebben we experten gezondheidseconomie bereid gevonden alle recente gegevens omtrent de impact van fitness op de gezondheid van het individu, de volksgezondheid en de maatschappij in het algemeen te verzamelen en de economische impact hiervan te berekenen.

We waren al langer overtuigd van de impact op het fysiek en mentaal welzijn van beoefenaars, maar vooral de economische impact heeft ons verrast. We zijn dan ook trots dat we dankzij de VUB en HICT dit rapport aan u kunnen voorstellen als leidraad en referentie voor maatregelen in het kader van de coronacrisis op korte termijn en de plaats van regelmatig en gecontroleerde fitnessbeoefening in de preventieve gezondheidszorg op lange termijn.

Français

Avec toutes les parties prenantes de son secteur, Fitness.be, l'association professionnelle belge de l'industrie du fitness, est depuis des années un protagoniste de la promotion d'un mode de vie sain. L'exercice régulier et contrôlé, tel que proposé dans les clubs de fitness, en est un élément essentiel. Les personnes qui font de l'exercice physique gagnent en résilience, en immunité et en bien-être physique et mental. Guider les gens vers cet objectif est la tâche principale des professionnels du fitness.

Pendant la pandémie, les experts et les responsables politiques ont cherché des méthodes pour protéger au maximum les citoyens. Cependant, force est de constater que très peu d'attention a été accordée aux soins de santé préventifs par la promotion d'un mode de vie sain. Il était pourtant clair dès le départ que cela augmenterait la résilience face au Covid-19, comme cela constitue un tampon contre diverses maladies liées au mode de vie.

Les hommes politiques ont raison de se laisser guider par des conseils fondés sur la recherche scientifique. En tant qu'association professionnelle, nous avons estimé qu'il était important d'assumer notre rôle sociétal dans ce dossier et de clarifier les arguments avancés par nos professionnels. Tant à la VUB qu'au Hict, nous avons trouvé des experts en économie de la santé disposés à collecter toutes les données récentes concernant l'impact du fitness sur la santé de l'individu, la santé publique et la société en général, et à en calculer l'impact économique.

Nous étions déjà convaincus de l'impact sur le bien-être physique et mental des pratiquants, mais l'impact économique nous a particulièrement surpris. Nous sommes donc fiers de pouvoir, grâce à la VUB et au Hict, vous présenter ce rapport comme un guide et une référence pour les mesures corona à court terme et pour la place de la pratique de fitness régulière et encadrée dans la prévention de la santé à long terme.

English

Fitness.be, the Belgian professional association for the fitness industry, and all industry stakeholders have spent many years promoting a healthy lifestyle. Regular and monitored exercise, as offered by gyms, is a crucial component of such a lifestyle, with gymgoers improving their resistance, immunity, and physical and mental wellbeing. Helping people to attain this is a core task of fitness professionals.

The coronavirus pandemic saw experts and politicians seeking out ways to provide citizens with the maximum level of protection. Unfortunately, very little attention has been paid to preventive healthcare through encouraging a healthy lifestyle – while it was clear from the get-go that this approach would increase resistance to Covid-19, just as it acts as a buffer against a range of lifestyle-related disorders.

Politicians are rightly guided by science-backed advice. As a professional association, we thus considered it important that we use the role we play in society as a stage for tackling this issue and create a degree of clarity with respect to the arguments cited by our professionals. Health economy experts at both the VUB university and Hict were happy to collate all the recent data concerning the effect of fitness on an individual's health, on public health, and on society in general, and to calculate its economic impact.

While we have always been convinced of the positive results on the physical and mental wellbeing of exercisers, the economic impact did surprise us. And so we are proud that, thanks to the efforts of the VUB and Hict, we can present to you this report that can serve as a guideline and point of reference when it comes to introducing measures in the short term for dealing with the pandemic and in the long term for making regular and supervised exercise a part of preventive healthcare.

Hict (Amber Werbrouck, Sebastian Vermeersch & Mats De Jaeger)

Nederlands

Preventie, en de rol van een gezonde levensstijl, is belangrijk. Toonaangevende organisaties in de gezondheidszorg zoals de WHO hameren al jaren op het belang van preventie en preventief gezondheidsbeleid. Toch is het niet eenvoudig om actief te investeren in preventie en gezond leven. Preventie betekent dat nu moet worden geïnvesteerd, terwijl de meest tastbare voordelen vaak pas later worden behaald. Het is algemeen bekend dat het bij het afwegen van opties moeilijk is een evenwicht te vinden tussen de behoeften op korte termijn en de voordelen op lange termijn. Een objectieve maatstaf voor het gezondheidseffect van preventie kan helpen het speelveld gelijk te maken.

Bij Hict zijn we er sterk van overtuigd dat objectieve argumenten nuttig en noodzakelijk zijn voor elke discussie en beslissing. Een gezondheidseconomische evaluatie kan een fantastisch instrument zijn om de waarde te kwantificeren en een perspectief te bieden op de impact van een interventie.

Om de impact van regelmatige en gestructureerde lichaamsbeweging te kwantificeren, bracht Hict haar expertise in lichaamsbeweging en gezondheidseconomische modellering samen. Mats De Jaeger en Amber Werbrouck hebben allebei een achtergrond in kinesitherapie en revalidatiewetenschappen en doken graag in de huidige literatuur over de effecten van lichaamsbeweging.

Amber Werbrouck en Sebastian Vermeersch gebruikten hun ervaring met gezondheidseconomische modellering om een bestaand gezondheidseconomisch model aan te passen en zo de langetermijnimpact van fitnessgebruik te kwantificeren. Wij hopen dat dit rapport een zinvolle basis voor discussie zal vormen en beleidsmakers kan helpen het belang van regelmatige en gestructureerde lichaamsbeweging in te zien, niet alleen vanuit een persoonlijk perspectief maar ook op een maatschappelijk perspectief.

Français

La prévention, et le rôle d'un mode de vie sain, sont importants. Les organisations de santé qui donnent le ton, telles que l'OMS, soulignent depuis des années l'importance de la prévention et des politiques de santé préventives. Pourtant, il n'est pas facile d'investir activement dans la prévention et un mode de vie sain. La prévention implique d'investir maintenant, alors que les bénéfices les plus tangibles ne sont souvent visibles que plus tard. Il est bien connu qu'il est difficile de trouver un équilibre entre les besoins à court terme et les avantages à long terme lorsqu'on évalue les options. Une mesure objective de l'impact de la prévention sur la santé peut contribuer à créer des règles du jeu équitables.

Chez Hict, nous croyons fermement que des arguments objectifs sont utiles et nécessaires à toute discussion et décision. Une évaluation économique de la santé peut constituer un excellent outil pour quantifier la valeur et offrir une perspective sur l'impact d'une intervention.

Pour quantifier l'impact d'une activité physique régulière et encadrée, Hict a réuni son expertise en matière d'activité physique et de modélisation économique de la santé. Mats De Jaeger et Amber Werbrouck ont tous deux une formation en physiothérapie et en sciences de la rééducation et étaient impatients de se plonger dans la littérature récente sur les effets de l'activité physique. Amber Werbrouck et Sebastian Vermeersch ont utilisé leur expérience en matière de modélisation économique de la santé pour adapter un modèle économique de la santé existant afin de quantifier l'impact à long terme de la pratique de fitness. Nous espérons que ce rapport constituera une base de discussion utile et aidera les décideurs à comprendre l'importance d'une activité physique régulière et encadrée, non seulement d'un point de vue personnel mais aussi sociétal.

English

Prevention, and the role of a healthy lifestyle, matter. Leading healthcare organizations such as the WHO have been stressing the importance of prevention and a preventive healthcare policy for many years. Nevertheless, actively investing in prevention and healthy living is not a straightforward task. The tangible benefits of today's outlay are only seen later, and it is universally acknowledged that it is notoriously difficult to balance short-term needs and long-term benefits when weighing the options. In this respect, an objective measure of the health impact of prevention can help to level the playing field.

At Hict we firmly believe that objective facts are beneficial to and necessary for every debate and resultant decision. A health economic evaluation can be a fantastic tool for quantifying value and providing perspective on the impact of an intervention.

To quantify the impact of regular and structured physical activity, Hict brought together its expertise in physical activity and health economic modelling. Mats De Jaeger and Amber Werbrouck both have a background in physiotherapy and rehabilitation sciences, and were happy to dive into the current literature on the effects of physical activity. Amber Werbrouck and Sebastian Vermeersch in turn brought their health economic modelling experience to the table to adapt an existing health economic model to quantify the long-term impact of gym usage. We hope that this report will create a meaningful basis for further discussion, and can help decision-makers to appreciate the importance of regular and structured physical activity from both a personal and also a societal perspective.

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Nederlands

In de periode 2020-2021 werd een reeks maatregelen genomen om de covid-19 pandemie in te dijken, wat een enorme impact heeft gehad op verschillende sectoren. Dat gold ook voor de fitness-sector: de fitnesscentra moesten dicht voor een langere periode. Onafgezien van het nut van dergelijke maatregelen op de circulatie van het virus sars-cov-2 is het belangrijk ook stil te staan bij de mogelijke negatieve gevolgen van zo'n maatregelen. De Vrije Universiteit Brussel en Hict voerden een gezondheidseconomische analyse uit om de lange-termijn impact van fitness, en de impact van sluiting, te becijferen.

Deze impact werden bepaald aan de hand van een gezondheidseconomisch model, waarbij het preventief effect van fysieke activiteit op het ontwikkelen van chronische ziektes in kaart gebracht werd. Het is wetenschappelijk aangetoond dat een verhoogd niveau van fysieke activiteit gerelateerd is aan een verlaagde kans om verschillende chronische ziektes te ontwikkelen, zowel op vlak van fysieke als mentale gezondheid. Daarnaast tonen studies aan dat er ook een onmiddellijk effect is op de kwaliteit van leven bij mensen die fysiek actiever zijn. Deze evidentie werd samengebracht in het model, waarbij ook rekening werd gehouden met data omtrent verhoogde medische kosten en mortaliteit, verminderde kwaliteit van leven, en productiviteitsverlies bij chronische ziektes. Er werd rekening gehouden met een selectie van chronische ziekten, met name diabetes, hart- en vaatziekten (beroerte en coronaire hartziekten), kanker (borst- en darmkanker), en mentale aandoeningen (depressie).

Leden van fitnessclubs halen gemiddeld een niveau van fysieke activiteit van 2.5 uur per week aan een matige tot intense intensiteit en voldoen hiermee ruimschoots aan de aanbevolen hoeveelheid fysieke activiteit volgens de Wereldgezondheidsorganisatie (WHO). Indien dat niveau wordt vergeleken met een fysiek inactievere levensstijl (m.a.w. niet meer voldoen aan de aanbevolen hoeveelheid fysieke activiteit), blijkt uit onze analyse dat dit gepaard gaat met een duidelijke maatschappelijke winst, die uitgedrukt kan worden in monetaire eenheden. Deze winst omvat een daling in medische kosten, een verbeterde productiviteit en een toename in gezondheid (meer zogenaamde Quality Adjusted Life Years – QALY's), uitgedrukt in monetaire waarden, en wordt in totaal geschat op 5121€ per fitnessbeoefenaar over een periode van 15 jaar. Indien men dit extrapoleert naar het totale aantal fitnessbeoefenaars in België, komt dit neer op bijna 7.2 miljard euro gecumuleerde maatschappelijke winst over 15 jaar.

Wat betekent dit nu, 5121€ per fitnessbeoefenaar? Om dit bedrag tastbaar te maken, kan men een vergelijking maken met de abonnementskost voor een fitnesser. Indien we ervan uitgaan dat een abonnement gemiddeld 35€ per maand kost, zal dit – gecorrigeerd voor zijn toekomstige waarde – neerkomen op 5164 € na 15 jaar. Als we dit bedrag vergelijken met 5121 € monetair baten na 15 jaar, wil dit eigenlijk zeggen dat de abonnementskost zo goed als volledig gerecupereerd wordt, onder de vorm van gezondheid en maatschappelijke winst. Men kan dus stellen dat in de fitnesssector de eindgebruiker betaalt: de fitnessbeoefenaars financieren hun eigen gezondheid, wat ten gunste komt voor de samenleving.

Om de winst op populatieniveau van 7.2 miljard euro te kaderen, kan men dit dan weer uitdrukken in functie van het aantal tewerkgestelden in de fitness-sector. Er zijn 5720 tewerkgestelden in de Belgische fitnessindustrie, wat wil zeggen dat elke werknemer gemiddeld voor een maatschappelijke bijdrage van meer dan 1.2 miljoen euro zorgt over een periode van 15 jaar. We kunnen het ook anders stellen, door een inschatting te maken van de loonkost voor deze tewerkgestelden in de fitnessindustrie. Het is moeilijk om hiervan een inschatting te maken, omdat er ook een aanzienlijk deel zelfstandig werkt in de sector, maar op basis van gegevens uit 2019 komt dit uit op een kost van ongeveer 881 miljoen euro over een periode van 15 jaar. Als we deze loonkost aftrekken van die 7.2 miljard, komen we nog steeds op een netto return van 6.2 miljard euro, of m.a.w. een return on investment van 713%. Dat betekent dat voor elke euro die geïnvesteerd wordt vanuit de private sector in tewerkstelling er meer dan 7 euro's maatschappelijk worden terugverdiend.

Tot slot werd ook nagegaan wat de impact mogelijks zou zijn van een tijdelijke sluiting. Stel dat een fitnessbeoefenaar voor 1 jaar zou terugvallen op een fysiek inactievere levensstijl, dan dalen de monetaire baten van fitness, opnieuw over een periode van 15 jaar, met 456€ per fitnessbeoefenaar. Geëxtrapoleerd op het totale aantal fitnessbeoefenaars in België, komt dit neer op een maatschappelijk verlies van bijna 640 miljoen euro. Met andere woorden, een relatief korte fysiek inactieve periode (1 jaar, over een totale tijdperiode van 15 jaar) heeft reeds een aanzienlijke maatschappelijke impact.

Tabel 1: Resultaten voor twee vergelijkende analyses: fitness vs. onvoldoende fysiek actief, en tijdelijke sluiting vs. volledige capaciteit. Alle resultaten werden uitgedrukt in monetaire termen.

Vergelijking	Op individueel niveau (per fitnessbeoefenaar)				Op populatieniveau
	Medische kosten	Productiviteits-verlies	Gewonnen QALY's	Incrementeel netto monetaire baten	
Fitness vs. onvoldoende fysiek actief	-153 €	-643 €	4 326 €	**5 121 €**	**7 158 847 294 €**
1-jaar lockdown vs. volledige capaciteit	16 €	77 €	-363 €	**-456 €**	**-637 010 576 €**

QALY: quality-adjusted life years (aan kwaliteit aangepaste levensjaren)

Dit model is, net als elk economisch model, een vereenvoudiging van de realiteit. De resultaten van ons model moeten dan ook geïnterpreteerd worden als een inschatting van de mogelijke impact. Een voorbeeld van zo'n vereenvouding is het volledig terugvallen op een fysiek inactieve levensstijl bij fitnessers. Dit wordt beschouwd als een aanname in het model. Uit een bevraging in november 2020 door de Belgische fitnessfederatie blijkt in elk geval dat 75% van de fitnessbeoefenaars minder sportte tijdens de sluiting.

Onze resultaten bevestigen dat het stimuleren van een actieve levensstijl belangrijk is voor de volksgezondheid, én een belangrijke kostimpact heeft door het beperken van medische en maatschappelijke kosten. Onze analyse geeft een concrete inschatting van de maatschappelijke impact van de Belgische fitnessindustie, alsook de impact van een tijdelijke sluiting. Hieruit blijkt dan ook dat, indien er besloten wordt om fitnesscentra te sluiten in het kader van de volksgezondheid, ook rekening moet gehouden worden met het potentiële verlies aan volksgezondheid.

Français

Au cours de la période 2020-2021, une série de mesures ont été prises pour contenir la pandémie de covid-19, qui a eu un impact énorme sur divers secteurs, dont le secteur du fitness : les centres de fitness ont dû fermer leurs portes pendant une période prolongée. Indépendamment de l'utilité de ces mesures pour endiguer la circulation du virus SARS-cov-2, il est important de considérer les éventuelles conséquences négatives desdites mesures. La Vrije Universiteit Brussel et Hict ont réalisé une analyse économique de la santé afin de quantifier l'impact à long terme du fitness, ainsi que l'impact de la fermeture.

Ces impacts ont été déterminés à l'aide d'un modèle économique de santé, qui a identifié l'effet préventif de l'activité physique sur le développement des maladies chroniques. Il est scientifiquement prouvé qu'un niveau accru d'activité physique est lié à une réduction du risque de développer diverses maladies chroniques, tant sur le plan de la santé physique que mentale. En outre, des études montrent qu'il y a également un effet immédiat sur la qualité de vie des personnes qui sont physiquement plus actives. Cette évidence a été rassemblée dans le modèle, qui a également pris en compte des données relatives à l'augmentation des coûts médicaux et à la mortalité, à la diminution de la qualité de vie et à la perte de productivité associées aux maladies chroniques. Une sélection de maladies chroniques a été prise en compte, à savoir le diabète, les maladies cardiovasculaires (accidents vasculaires cérébraux et maladies coronariennes), le cancer (cancer du sein et du côlon) et les troubles mentaux (dépression).

Les membres des clubs de fitness atteignent un niveau moyen d'activité physique de 2,5 heures par semaine à une intensité modérée à élevée, répondant ainsi largement au niveau d'activité physique recommandé par l'Organisation mondiale de la Santé (OMS). Comparé à un mode de vie physiquement plus inactif (c'est-à-dire ne respectant plus le niveau d'activité physique recommandé), notre analyse montre que ce niveau présente un avantage sociétal clair, qui peut être exprimé en unités monétaires. Ce gain comprend une diminution des coûts médicaux, une augmentation de la productivité et une amélioration de la santé (plus connues sous le nom d'années de vie pondérées par la qualité - QALY), exprimées en valeurs monétaires, et est estimé au total à 5121 € par pratiquant de fitness sur une période de 15 ans. Si l'on extrapole ce chiffre au nombre total de pratiquants de fitness en Belgique, cela représente un gain sociétal cumulé de près de 7,2 milliards d'euros sur 15 ans.

Qu'est-ce que cela signifie, 5121 € par pratiquant de fitness ? Pour rendre ce montant tangible, on peut faire une comparaison avec le coût de l'abonnement d'un pratiquant de fitness. Si nous supposons qu'un abonnement coûte en moyenne 35 euros par mois, ce montant - corrigé pour sa valeur future - s'élèvera à 5164 euros après 15 ans. Si l'on compare ce montant aux 5121 € de bénéfices monétaires après 15 ans, cela signifie que le coût de l'abonnement est presque entièrement récupéré sous forme de bénéfices pour la santé et la société. On peut donc dire que dans le secteur du fitness, c'est l'utilisateur final qui paie : les pratiquants de fitness financent leur propre santé, ce qui profite à la société.

Pour mettre en perspective le bénéfice de 7,2 milliards d'euros par rapport à la population, on peut l'exprimer en fonction du nombre de personnes employées dans le secteur du fitness. Le secteur belge du fitness emploie 5720 personnes, ce qui signifie qu'en moyenne, chaque collaborateur apporte une contribution sociétale de plus de 1,2 million d'euros sur une période de 15 ans. On pourait aussi faire une estimation des coûts salariaux de ces personnes employées dans le secteur du fitness. C’est un exercice difficile, car il existe également une proportion importante de personnes travaillant de manière indépendante dans le secteur, mais sur la base des données de 2019, cela représente un coût d'environ 881 millions d'euros sur une période de 15 ans. Si nous déduisons ce coût salarial des 7,2 milliards, cela donne encore un rendement net de 6,2 milliards d'euros, soit un retour sur investissement de 713 %. Cela signifie que pour chaque euro investi par le secteur privé dans l'emploi, plus de 7 euros sont récupérés au niveau sociétal.

Enfin, l'impact éventuel d'une fermeture temporaire a également été examiné. Supposons qu'un pratiquant de fitness revienne à un mode de vie plus inactif pendant un an, alors, toujours sur une période de 15 ans, les avantages monétaires du fitness diminueraient de 456 euros par pratiquant de fitness. Extrapolé au nombre total de pratiquants de fitness en Belgique, cela représente une perte sociétale de près de 640 millions d'euros. En d'autres termes, une période relativement courte d'inactivité (1 an, sur une période totale de 15 ans) a déjà un impact sociétal considérable.

Tableau 1 : Résultats de deux analyses comparatives : fitness vs. activité physique insuffisante, et fermeture temporaire vs. pleine capacité. Tous les résultats ont été exprimés en termes monétaires.

Comparaison	Au niveau individuel (par pratiquant de fitness)				Au niveau de la population
	Frais médicaux	Perte de productivité	QALY gagnés	Bénéfice monétaire incrémentiel net	
Fitness vs. activité physique insuffisante	-153 €	-643 €	4 326 €	**5 121 €**	**7 158 847 294 €**
1 an de confinement vs. pleine capacité	16 €	77 €	-363 €	**-456 €**	**-637 010 576 €**

QALY : années de vie pondérées par la qualité (quality-adjusted life years)

Ce modèle, comme tout modèle économique, est une simplification de la réalité. Les résultats de notre modèle doivent donc être interprétés comme une estimation de l'impact possible. Un exemple d'une telle simplification est le retour complet à un mode de vie physiquement inactif chez les pratiquants de fitness. Ceci est considéré comme une hypothèse dans le modèle. Quoi qu'il en soit, une enquête menée en novembre 2020 par la Fédération belge du fitness montre que 75 % des pratiquants de fitness ont fait moins d'exercice pendant la fermeture.

Nos résultats confirment que la promotion d'un mode de vie actif est importante pour la santé publique et a un impact important sur les coûts, à savoir une réduction des coûts médicaux et sociétaux. Notre analyse fournit une estimation concrète de l'impact sociétal de l'industrie belge du fitness, ainsi que de l'impact d'une fermeture temporaire. Elle montre que si la décision est prise de fermer des centres de fitness pour des raisons de santé publique, la perte potentielle de santé publique doit également être prise en compte.

English

A series of measures were implemented in 2020 and 2021 to contain the Covid-19 pandemic that had a huge impact on a range of sectors. The exercise industry was not exempt, and fitness centers were forced to close for an extended period. Irrespective of whether such measures served to curtail the SARS-CoV-2 virus, it remains important that we also consider their possible negative consequences. The Vrije Universiteit Brussel and Hict conducted a health economic evaluation in order to quantify their long-term impact on fitness and the effect of closing the centers.

The impact was determined using a health economic model, which identified the preventive effect of physical activity on the development of chronic diseases. It is scientifically proven that a rise in physical activity is related to a decreased risk of developing various chronic diseases, both in terms of physical and mental health. Moreover, studies show that there is also an immediate rise in quality of life when people become more physically active. This evidence was collated in the model, which also employed data on increased medical costs and mortality, reduced quality of life, and a decrease in productivity as a result of chronic diseases. A selection of chronic diseases was considered: diabetes, cardiovascular disease (stroke and coronary heart disease), cancer (breast and colon cancer), and mental illness (depression).

On average, members of gyms spend 2.5 hours per week performing moderate to intense physical activity, and thus certainly meet the level of physical activity recommended by the World Health Organization (WHO). Comparing that to a more physically inactive lifestyle (i.e., where the recommended amount of physical activity is not met), our analysis shows that there is a clear societal gain, one that can be expressed in monetary units. This gain includes a decrease in medical costs, improved productivity, and an increase in health (more quality-adjusted life years - QALYs), estimated in monetary terms at €5,121 per exerciser over a period of 15 years. If one extrapolates that outcome to the total number of gymgoers in Belgium, this amounts to almost €7.2 billion in accumulated societal gain over 15 years.

But what does that actually mean - €5,121 per exerciser? To put it into tangible terms, we can compare it to membership fees for a gym. If we assume that membership fees are on average of €35 per month, then that - corrected for future value - amounts to €5,164 over 15 years. Next we compare that figure to the €5,121 monetary gain in the same period of time and the result is that membership fees are almost completely recovered, in the form of health and societal gains. One can consequently assert that, in the fitness industry, the end-user pays: people who exercise finance their own health, and that can only benefit society.

To put that profit of €7.2 billion into context at the level of the national population, the figure can in turn be expressed as a function of the number of people employed in the fitness industry. There are 5,720 people employed in the Belgian fitness industry, which means that on average each employee makes a societal contribution of more than €1.2 million over that 15-year period. Another way to look at it is to estimate the wage costs for this staff. That is a difficult task, given that a significant proportion of those working in the fitness industry are self-employed, but based on data from 2019 the figure stands at around €881 million over a 15-year period. If we subtract this cost of labor from that figure of €7.2 billion, we still arrive at a net return of €6.2 billion, or a return on investment of 713%. This means that for every euro invested in employment by the private sector, more than €7 are earned back by society.

Finally, the impact of the temporary closure of gyms was also examined. Assuming that a gymgoer reverts to a less physically active lifestyle for a year, the monetary gains from exercising - again over a 15-year period - fall by €456 per exerciser. Extrapolated to the total number of gymgoers in Belgium, this amounts to a societal loss of almost €640 million. In other words, a relatively short period of physical inactivity (1 year, over a total period of 15 years) already has a significant social impact.

Table 1: Results from two comparative analyses: fitness vs. insufficient physical activity, and temporary closure vs. full capacity. All results are expressed in monetary terms.

Comparison	On an individual level (per exerciser)				At population level
	Medical expenses	Productivity loss	QALYs gained	Incremental net monetary benefits	
Fitness vs. inadequately physically active	-€153	-€643	€4,326	**€5,121**	**€7,158,847,294**
1-year lockdown vs. full capacity	€16	€77	-€363	**-€456**	**-€637,010,576**

QALY: quality-adjusted life years

As is the case with any economic model, this model is a simplification, and so the results should be viewed as merely an estimate of the possible impact. An example of such a simplification is the idea that fitness enthusiasts would revert completely to a physically inactive lifestyle, which serves as an assumption in our model. But it remains a fact that, in a November 2020 survey conducted by the Belgian Fitness Federation, 75% of gymgoers said the exercised less during the closure of the fitness centers.
Our results confirm that promoting an active lifestyle is important to public health and has a significant impact upon costs by reducing medical and societal expenditure. Our analysis provides a concrete estimate of the impact the Belgian fitness industry has on society, as well as the impact of a temporary closure. This demonstrates that, if and when the decision is taken to close fitness centers on the grounds of public health, the potential loss of public health deserves equal consideration.

The potential health and economic impact of gym usage in Belgium

Context

There is an abundance of scientific evidence for the health benefits related to physical activity (PA). Consequently, physical inactivity is a behavioural risk factor for the development of a broad spectrum of chronic diseases, including cardiovascular diseases, cancer, diabetes mellitus, hypertension, obesity, and even depressive disorders (Warburton, Nicol, and Bredin 2006). Hence, physical inactivity does not only negatively influence physical well-being but also mental health. Physical activity (PA) can be defined as "any bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen, Powell, and Christenson 1985). Physically active individuals are generally regarded as being healthier in comparison to their physically less active counterparts. In order to be health-enhancing, it is recommended that people engage regularly in physical activity in which energy expenditure is well above resting levels (e.g., walking). The World Health Organization (WHO) global recommendations on physical activity state that adults aged 18–64 years should do at least 150 min of moderate-intensity aerobic physical activity throughout the week, or do at least 75 min of vigorous-intensity aerobic physical activity throughout the week, or an equivalent combination of moderate- and vigorous-intensity activity (World Health Organization 2020). WHO defined moderate-intensity physical activity as "any activity with a MET value between 3 and 5.9 and vigorous-intensity physical activity as ≥6 MET". One MET is defined as "the resting metabolic rate, that is, the amount of oxygen consumed at rest, sitting quietly in a chair" (Jetté, Sidney, and Blümchen 1990). The majority of physical activities and exercises performed in a fitness center can be considered as moderate-to-vigorous intensity physical activities (Ainsworth et al. 2011).

Amidst a global pandemic, caused by Covid-19, policy makers were forced to make tough decisions to prevent the coronavirus sars-cov-2 from spreading. In Belgium, these decisions have had a huge impact on numerous industries. The fitness industry was particularly affected, as the regulations and safety measures eventually led to a complete shutdown of the sector for a considerable period of time. This did not only cause unemployment in the sector itself, but also resulted in reduced PA in the general population, including gym club members. In 2017, 14.6% of the population older than 15 years participated in any fitness activity (Scheerder, Vehmas, and Helsen 2020).

To this day, the health economic impact of gym usage in Belgium has not yet been described in detail. Furthermore, the actual impact of the complete closure of all Belgian gym clubs for the specific time period remains unclear to this day. The overall aim of this project is to assess the potential health and economic impact of PA performed in gym clubs taking into account the medical and psychosocial wellbeing of the Belgian gym users. In addition, the impact of a nationwide closure of the Belgian gym clubs and the corresponding decrease in PA can be estimated. The results of this health economic analysis will identify and evaluate the impact of the governmental Covid-19 safety measures, providing knowledge in case of future similar health crises.

To determine the health economic impact in detail, a phased approach is used in this project. The first step is to provide an overview of recent, relevant scientific literature. In order to quantify the health economic impact of PA, scientific evidence on the association between PA and different long-term effects (e.g., chronic diseases) and short-term effects (e.g., quality of life and psychosocial well-being) needs to be reported. A visual representation of the different health-related benefits of PA is show in Figure 1. Results of the literature search will be integrated into the health-economic evaluation, which will ultimately result in the quantification of the health and economic effects of gym usage.

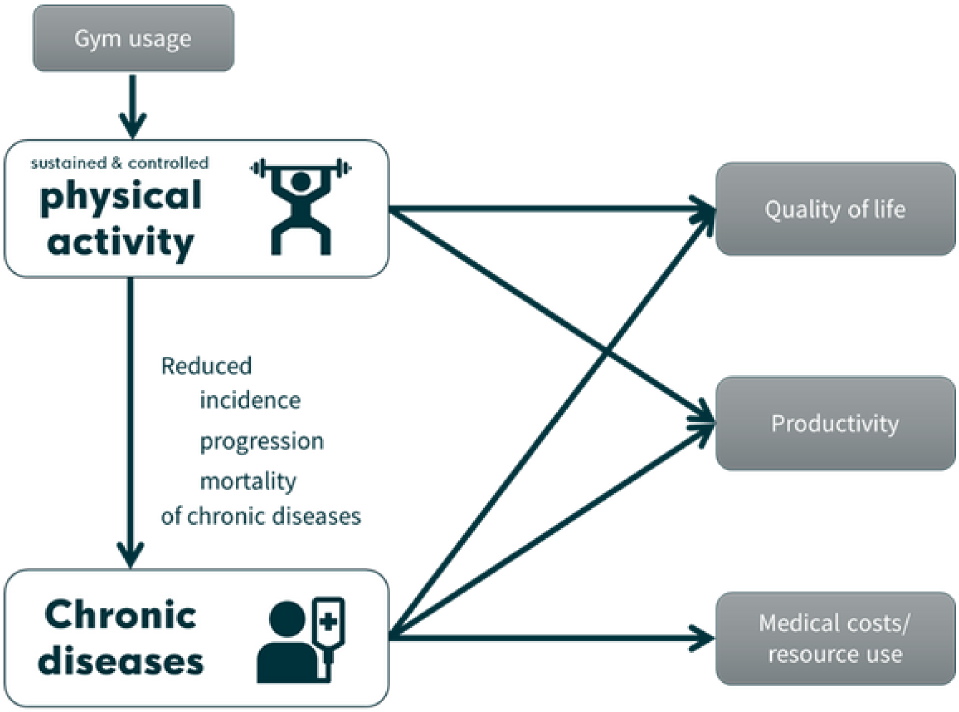


Figure 1. Important building blocks for the health economic analysis and their relationships.

Part One | Literature search

1. Methodology

The aim of our literature search is to provide a broad overview of the health and economic impact of physical activity, which can be applicable in the setting of fitness centers. To avoid selection bias, we used a structured literature search approach. The search strategy of this rapid review was tailored to identify relevant literature that can be used for our health-economic analysis . This means the search strings (i.e. combination of search terms) are focused on the main blocks and relationships presented in Figure 1. The literature search was developed for MEDLINE (via PubMed), and built up using a cascading system. First, the most important MeSH-terms (Medical Subject Headings) were selected, in relation to the topic (see Table 1).

Mesh-terms were combined using Boolean operators (AND, OR) in PubMed. When the number of hits was too high (more than 150 hits per assessed association), the search was further specified by only including recent literature (<5 years), and/or the search was focused on the most important source of information, according to evidence-based medicine (EBM), namely systematic reviews (SR). When the number of hits were too low (< 10), the search was broadened by also including free terms as search terms. Finally, the reference list of included articles was screened for relevant articles that were not identified during our structured literature search. Articles were selected based on title and abstract. A single reviewer conducted the literature search and screened the abstracts based on population, intervention and outcome of interest. Afterwards a second reviewer conducted a quality check on the selected studies. No formal quality assessments were performed.

Table 1. Overview of relevant MeSH-terms.

Term in model	MeSH	MEDLINE definition
Gym	Fitness center	Facilities having programs intended to promote and maintain a state of physical well-being for optimal performance and health.
Fitness/physical activity	Physical fitness	The ability to carry out daily tasks and perform physical activities in a highly functional state, often as a result of physical conditioning.
	Exercise	Physical activity which is usually regular and done with the intention of improving or maintaining physical fitness or health. Contrast with physical exertion which is concerned largely with the physiologic and metabolic response to energy expenditure
MET	Metabolic equivalent	A measurement of oxygen uptake in a sitting, resting person (resting oxygen consumption), varying with age, sex, race, and other factors. In a normal adult man, one MET is approximately 3.5 ml O2/kg/min of body weight. Oxygen uptake during activities or work can be measured in METs which can be used to determine health status and exercise prescription.
Chronic disease	Chronic disease	Diseases which have one or more of the following characteristics: they are permanent, leave residual disability, are caused by nonreversible pathological alteration, require special training of the patient for rehabilitation, or may be expected to require a long period of supervision, observation, or care.
	Non-communicable disease	Diseases which are typically non-infectious in origin and do not transmit from an affected individual to others. The four main types of noncommunicable diseases are cardiovascular diseases (e.g., heart attacks and stroke), cancer, chronic respiratory diseases (e.g., chronic obstructive pulmonary disease and asthma) and diabetes mellitus
Stroke	Stroke	A group of pathological conditions characterized by sudden, non-convulsive loss of neurological function due to brain ischemia or intracranial haemorrhages. Stroke is classified by the type of tissue necrosis, such as the anatomic location, vasculature involved, etiology, age of the affected individual, and haemorrhagic vs. non-haemorrhagic nature.
Diabetes type 2	Diabetes mellitus type 2	A subclass of diabetes mellitus that is not insulin-responsive or dependent. It is characterized initially by insulin resistance and hyperinsulinemia; and eventually by glucose intolerance; hyperglycaemia; and overt diabetes. Type 2 diabetes mellitus is no longer considered a disease exclusively found in adults. Patients seldom develop ketosis but often exhibit obesity.
Depression	Depressive disorder	An affective disorder manifested by either a dysphoric mood or loss of interest or pleasure in usual activities. The mood disturbance is prominent and relatively persistent.
	Depression	Depressive states usually of moderate intensity in contrast with major depression present in neurotic and psychotic disorders.
Coronary heart disease	Coronary disease	An imbalance between myocardial functional requirements and the capacity of the coronary vessels to supply sufficient blood flow. It is a form of myocardial ischemia (insufficient blood supply to the heart muscle) caused by a decreased capacity of the coronary vessels.
Breast cancer	Breast neoplasms	Tumours or cancer of the human breast.
Colon cancer	Colonic neoplasms	Tumours or cancer of the colon.
Productivity	Absenteeism	Chronic absence from work or other duty.
	Presenteeism	Reporting for work despite feeling ill.
Quality of life	Quality of life	A generic concept reflecting concern with the modification and enhancement of life attributes, e.g., physical, political, moral, social environment as well as health and disease.
Medical costs	Health care costs	The actual costs of providing services related to the delivery of health care, including the costs of procedures, therapies, and medications. It is differentiated from health expenditures, which refers to the amount of money paid for the services, and from fees, which refers to the amount charged, regardless of cost.
	Health expenditures	The amounts spent by individuals, groups, nations, or private or public organizations for total health care and/or its various components. These amounts may or may not be equivalent to the actual costs (health care costs) and may or may not be shared among the patient, insurers, and/or employers.
Progression	Disease progression	The worsening of a disease over time. This concept is most often used for chronic and incurable diseases where the stage of the disease is an important determinant of therapy and prognosis.

An overview of the structured approach is shown in Figure 2. An extensive overview of the search strategy is included in the Appendix. The literature search was based on the defined MeSH-terms, publication date and quality of evidence (systematic review and/or (large) cohort studies), furthermore no strict in- and exclusion criteria were utilized.

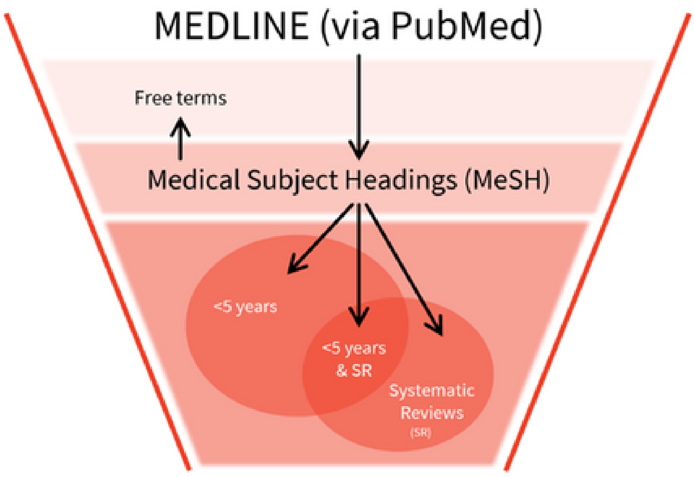


Figure 2. Cascading system for the structured literature search.

2. Conclusions

Table 2 and Figure 3 provide an overview of the identified literature. Evidence tables as well as high-level conclusions per section are provided in the Appendix.

Table 2. Number of relevant articles per section (++: strong evidence; +: sufficient evidence; -: insufficient evidence).

	No. of reviews		No. of original studies		Strength of evidence
	Systematic	Other reviews	Large cohort*	Cohort	
Gym usage & Physical activity	1	-	2	1	-
Physical activity & Incidence of chronic diseases	8	2	1	-	+
Physical activity & Progression of chronic diseases	4	-	1	2	++
Physical activity & Mortality	9	1	3	2	++
Chronic disease & Quality of life	2	-	-	-	+
Chronic disease & Absenteeism	2	-	4	1	+
Chronic disease & Costs	3	-	2	2	++
Physical activity & Absenteeism	-	-	-	2	-
Physical activity & Quality of life and well-being	5	-	2	-	-

** A distinction was made between studies with a sample size larger than 10 000 participants (i.e. large cohort studies) and cohort studies with a smaller sample size.*

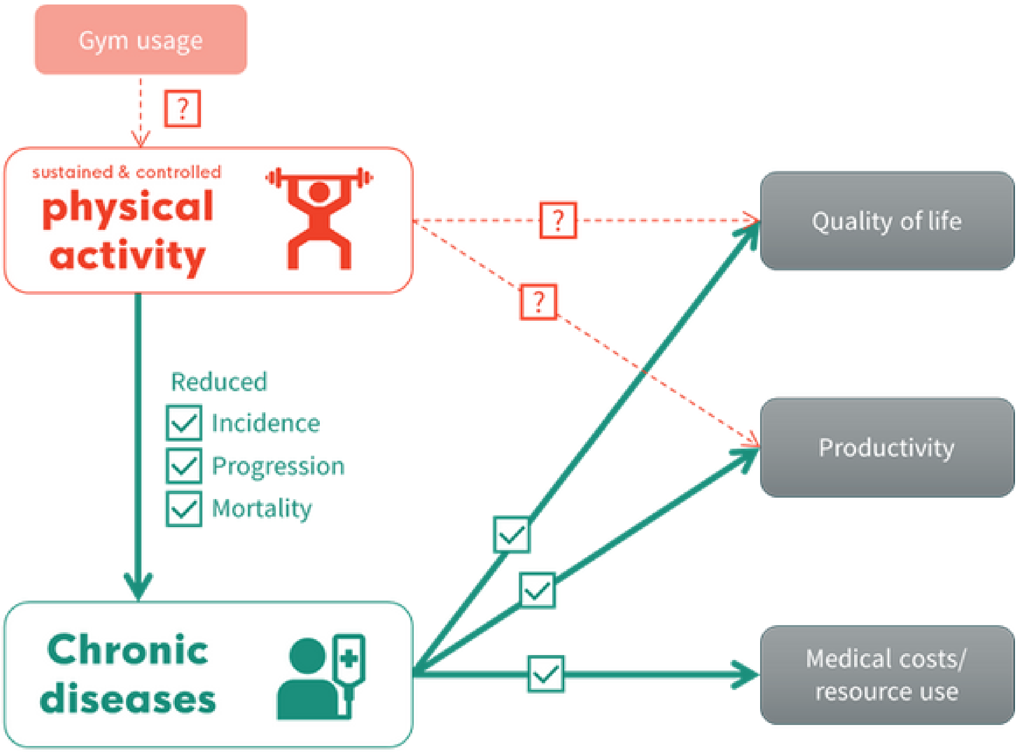
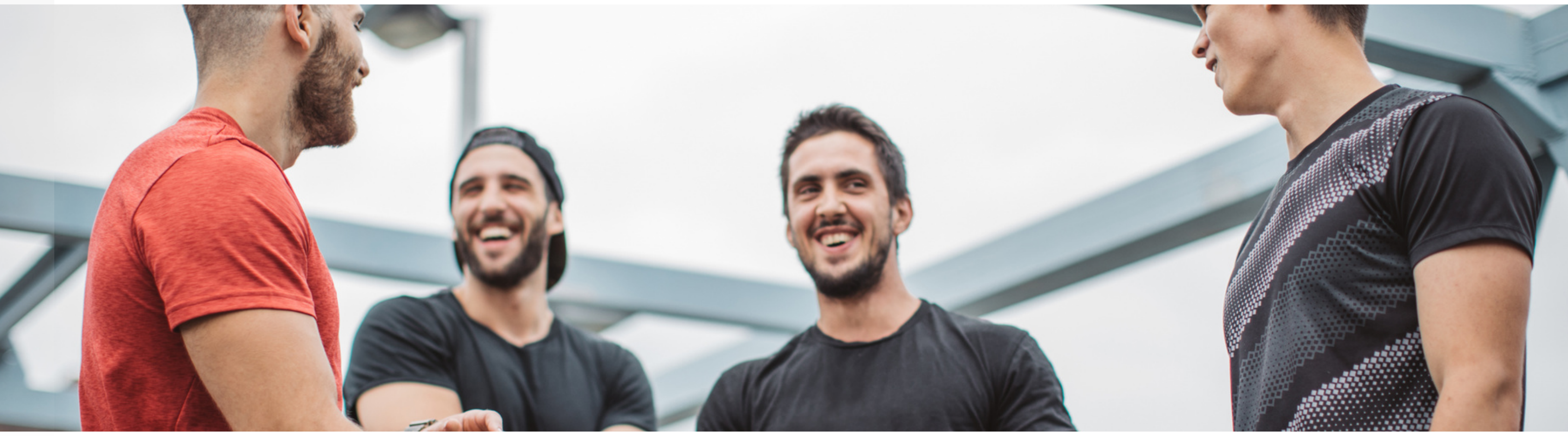


Figure 3. Overview of the results of the literature search.

This structured rapid review is focused on high quality evidence, mainly including systematic reviews or large sample cohort studies. A possible limitation of our approach is that some evidence could be overlooked by our pragmatic approach. However, the following overall conclusions could be made:

- The associations between PA and development of chronic diseases as well as mortality appears to be well established. In addition, there is some evidence that PA can also reduce disease progression.
- There is a clear association between chronic diseases and relevant health and economic outcomes such as quality of life, medical costs and absenteeism.
- The direct association between PA and these relevant outcomes (quality of life, costs and productivity) appears to be less established, in comparison to the link between chronic diseases and those outcomes. However, the latter is probably more relevant in the health-economic analysis.
- There appears to be a lack of evidence regarding (gains in) physical activity levels in gym members. Other approaches (e.g. local databases, or assumptions) may be needed to cover this aspect in the health-economic model.

Based on these findings, we can conclude that there is a large body of evidence supporting the health benefits of PA, recently underlined by the new WHO 2020 guidelines on physical activity and sedentary behaviour (Bull et al. 2020). Many of the relations for which data will be needed to populate a health-economic model are well-established in the literature.



Our objective was to estimate the potential health and economic effects of gym usage in Belgium. In order to achieve this goal, an existing health-economic model (Werbrouck 2021; Schepers and Annemans 2018; N. Verhaeghe, De Greve, and Annemans 2016; Nick Verhaeghe et al. 2014; Pil et al. 2014; Willems et al. 2020; De Smedt et al. 2012; Annemans et al. 2007) was adapted to estimate the expected gains or costs related to quality of life, medical costs, and productivity.

1. Methodology

1.1. Model structure

The health-economic model used is an age- and gender-specific Markov model. All individuals start in a disease-free state, assuming a healthy population as target population. Each year (i.e. the cycle length of the model), each individual has a probability to develop a particular disease. The model includes six different chronic diseases, for which the benefits of PA are well-established (see Part One):

- Stroke;
- Coronary heart disease (CHD);
- Colorectal cancer;
- Breast cancer;
- Type 2 diabetes mellitus (T2DM);
- Depressive disorders.
-

In each cycle an individual has a probability to die. Hence, an absorbing state "Dead" was also included in the model. The model structure is presented in Figure 4.

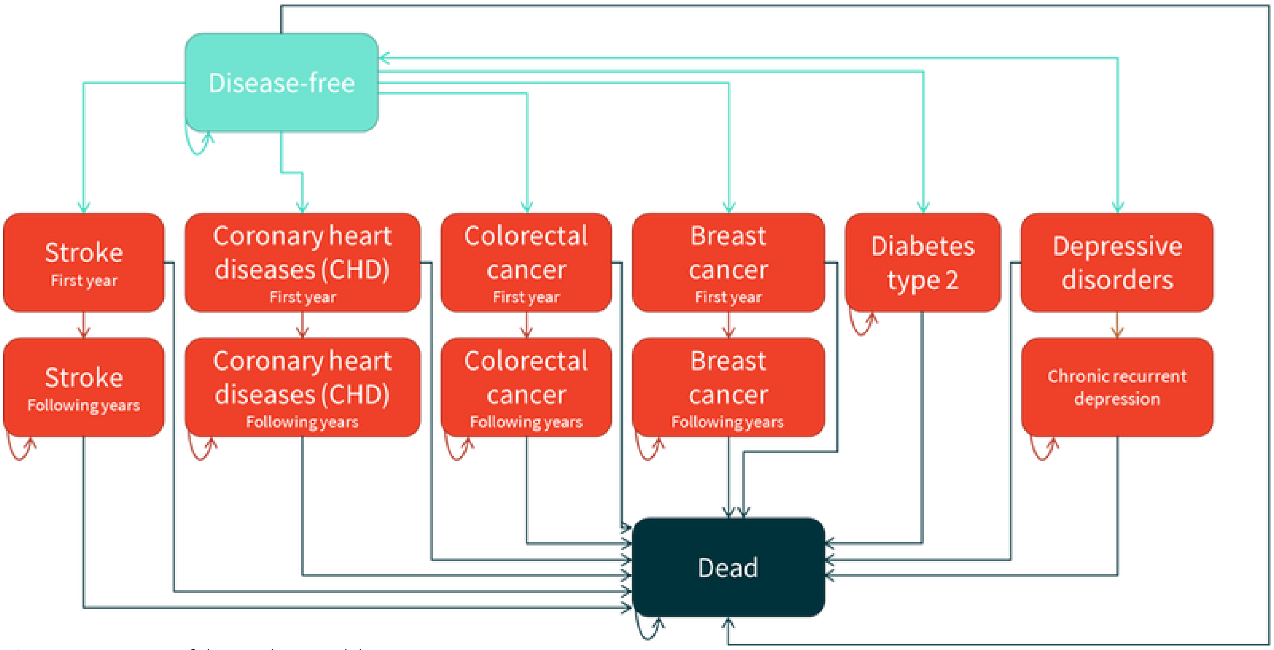


Figure 4. Structure of the Markov model.

Typical for a Markov model, an individual can only be in one health state at a certain point in time. An important limitation of this model structure is therefore that once a person in the model has developed a specific disease state, it is not possible to progress or transition to another disease state. This might lead to an underestimation of the occurrences of chronic diseases in the model. There are different options to limit this impact in Markov models (for example, include transition probabilities between different disease states, add combination states (e.g. colorectal cancer, combined with stroke)). However, these options often lead to gaps in data availability regarding disease costs and quality of life. In this model, the decision was made to use a more pragmatic solution, by applying a recalibration on the incidence rates. With this recalibration, incidence rates are not only applied to people in the disease-free state, but also to those that have already developed another disease. In other words, the model now allows that people with one chronic disease can still develop another chronic disease. As shown in Figure 5, this leads to a higher proportion of people with a chronic disease. A scenario analysis without this recalibration was done to assess its structural impact.

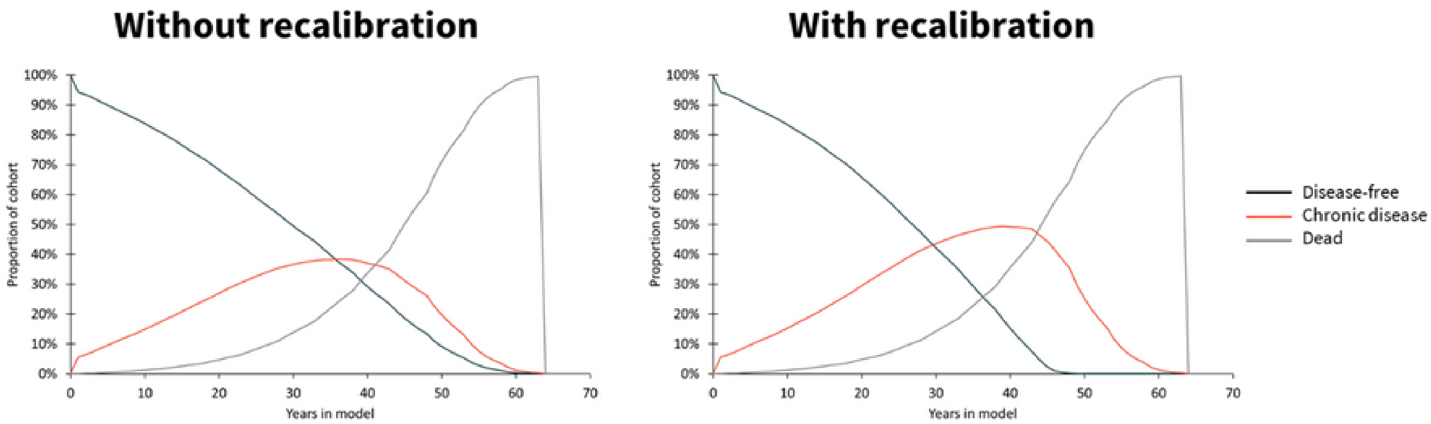


Figure 5. After recalibration, a higher proportion of the cohort would develop a disease.

1.2. Model properties

The KCE guidelines (Cleemput et al. 2012) recommend using a time horizon that is long enough to capture all the clinical outcomes and costs associated to the disease and the treatment. Taking into consideration the preventive nature of physical activity, a lifetime time horizon (e.g. until 100 years) can be justified. However, a longer time horizon introduces an increase in uncertainty. Therefore it was decided to apply a 15-year time horizon in the base case analysis. Longer and shorter time horizons (from 5 years to 20 years) are further explored in scenario analyses.
The model applies a one-year cycle length. In other words, every year, an individual can transition from one health state to another (or stay in the same health state). Each health state is then associated with specific health care costs and health outcomes.

1.3. Transition probabilities

Age- and gender-specific mortality rates and the probabilities to develop a particular disease (derived from incidence rates) were retrieved from the Global Burden of Disease study (http://ghdx.healthdata.org/gbd-results-tool). The data is provided in Appendix 3.
For all diseases except depressive disorders, it was not possible to return to the disease-free state (i.e. the state in which the entire cohort started). For depressive disorders, literature suggests that 84.8% of patients recover from depression after one year (Bottomley et al. 2010). Hence, the assumption was made that the remaining 15.2% will experience chronic, recurrent depressive disorders.
For T2DM, adequate disease management has the potential to completely limit disease symptoms. However, returning to the disease-free state was not allowed, as the input parameters (mortality, costs, utilities) considers diagnosed T2DM and not only symptomatic T2DM.
The increased mortality risks, once an individual developed a particular disease, were retrieved from different sources (see table 3). For stroke and CHD, case-fatality rates were included (see Table 4), based on a retrospective study conducted in France (Cottel et al. 2018) see Table 4.

Table 3. Hazard ratios (HR), used to calculate increased mortality probabilities.

	HR	95% CI	Source
Stroke			
< 50 years	5.6	5.3 – 5.9	(Ekker et al. 2019)
≥ 50 years	2.2	1.9 – 2.5	(Mathisen et al. 2016)
Coronary heart disease			
(all)	1	0.8 – 1.2*	
Colorectal cancer			Belgian cancer registry
Male	6.1	4.88 – 7.32*	
Female	5.64	4.51 – 6.77*	
Breast cancer			Belgian cancer registry
Male	4.84	3.87 – 5.81*	
Female	2.57	2.06 – 3.08*	
Diabetes			
(all)	1.68	1.52 – 1.87	(S. Li et al. 2019)
Depressive disorders			
First year	1	0.8 – 1.2*	
Chronic recurrent	1.35	1.21 – 1.5	(Reutfors et al. 2018)

** When confidence intervals were not reported, a confidence interval of plus/minus 0.2*HR is assumed. This variation was derived from the other confidence intervals of hazard ratios in this model. CI: confidence interval.*

Table 4. Case fatality rates for stroke and CHD.

	Mean	95% CI	Source
Stroke			
< 60 years	13%	9% - 16%	(Cottel et al. 2018)
≥ 60 years	16%	13% - 19%	(Cottel et al. 2018)
Coronary heart disease			
< 60 years	19%	15% - 22%	(Cottel et al. 2018)
≥ 60 years	25%	21% - 28%	(Cottel et al. 2018)

1.4. Compared alternatives

Several alternatives are tested by running through the same model structure. The included alternatives are:

- Alternative in which the cohort is insufficiently physically active. For this alternative, epidemiological data are applied to estimate the disease costs and QALYs.
- Alternative in which the cohort goes to the gym. For this alternative, data from the Belgian fitness industry were used to estimate the level of PA.
- In-between alternative, which simulates a temporary closure of gyms (i.e. a lockdown situation).

By making specific changes in some input parameters, differences will be induced between the different alternatives leading to different comparisons (Alternative 1 versus Alternative 2 – see Figure 6 – or versus Alternative 3,…)

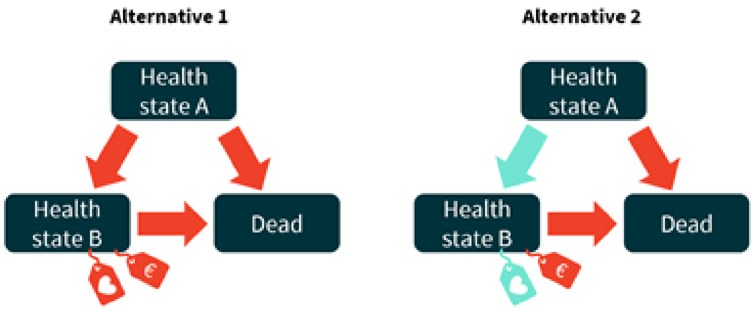


Figure 6. Basic principle of a Markov model. A hypothetical example is provided of parameters that differ (in light blue: reduced transition probably, increased health effect) in the second alternative.

1.5. Effect of gym usage on physical activity levels and health

Based on Belgian data from a large fitness chain and expert opinion, it appeared that members visit their gym about **2.5 times per week** (JIMS Fitness - data from October 2021). Based on expert opinion, it is assumed that gym members would be 60 minutes physically active during their visit. Moreover, a **moderate- to vigorous** PA (MVPA) was assumed during this visit. Taking into account the number of visits/week and the average PA time per visit, a total PA level can be calculated and expressed in MET min/week, a standard index utilised for describing the energy cost of a specific activity (Ainsworth et al. 2011). The MET values related to the different levels of PA intensity are retrieved from the IPAQ (1) scoring protocol. Based on this calculation, gym participants can be classified at a 'moderate' level of PA (i.e., "total physical activity of at least 600 MET min/week"). Furthermore, taking into account the WHO global recommendations (2) on physical activity for health it can be concluded that gym participants meet this guideline (2.5 visits/week * 60 minutes of moderate- to vigorous PA/visit = 150 minutes of moderate- to vigorous PA per week).

	Distribution	Frequency (/week)	Duration (/session)	MET scoring	Total (MET min/week)
Light	-	2.5	60 min	3.3 METs	**0**
Moderate	50%			4 METs	**300**
Vigorous	50%			8 METs	**600**
					900

Based on the evidence in literature on the health benefits of PA, it can be concluded that these levels of PA (expressed in MET min/week or minutes of MVPA per week) can be linked to a reduced risk to develop the included diseases described above. For all diseases, except depressive disorders, data were derived from the Global Burden of Disease study (Kyu et al. 2016). Literature has shown that in those diseases, risk reductions are dose-dependent, implying that a higher level of PA will lead to higher risk reductions (see Figure 7). The reduced risk of depressive disorders was based on a prospective study (Lucas et al. 2011).

[1] The International Physical Activity Questionnaire is an instrument that was introduced in two different versions to obtain comparable estimates of physical activity (https://sites.google.com/site/theipaq/)
[2] "Adults aged 18–64 years should do at least 150 min of moderate-intensity aerobic physical activity throughout the week, or do at least 75 min of vigorous-intensity aerobic physical activity throughout the week, or an equivalent combination of moderate- and vigorous-intensity activity" (World Health Organization 2020)

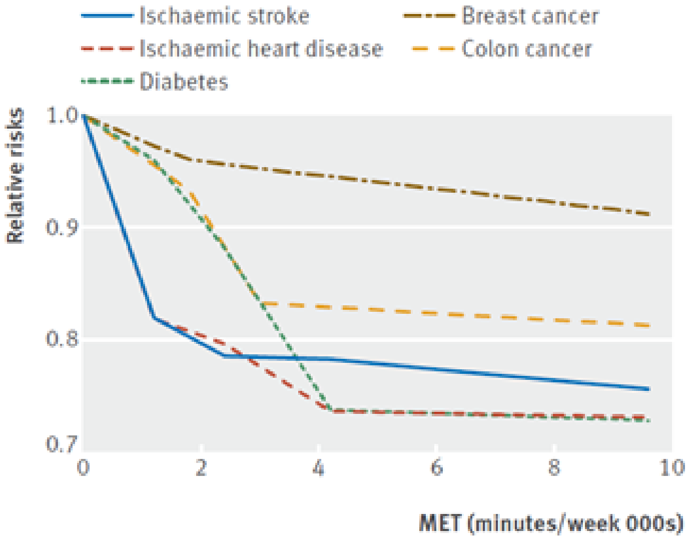


Figure 7. Continuous risk curves for association between physical activity and breast cancer, colon cancer, diabetes, ischemic heart disease, and ischemic stroke. Source: Kyu et al. 2016

1.6. Outcomes

The perspective defines the point of view adopted when deciding which types of costs and health benefits are to be included in an economic evaluation. Typical viewpoints are those of the patient, hospital/clinic, healthcare system or society. The broadest perspective is societal, which reflects a full range of social opportunity costs associated with different interventions (York Health Economics Consortium 2016). This broad **societal perspective** was considered in this analysis. For this model, quality-adjusted life years (QALYs), medical costs, and productivity was included. All outcomes are monetarised.

Although a broad range of cost categories (direct, indirect as well as intangible costs) were included, there are several other cost components that could be considered within these categories (see Figure 8). It was decided to focus on medical costs, costs related to productivity losses, and costs related to loss of QoL and life expectancy. This decision was made because those costs can be considered the major cost drivers.

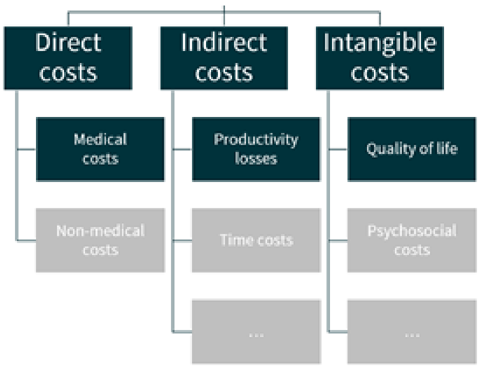
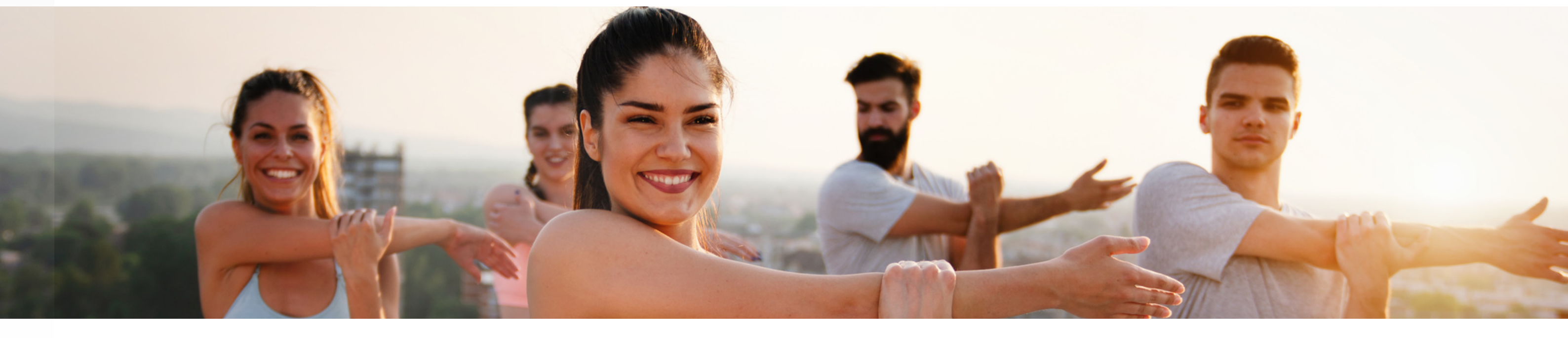


Figure 8. Overview of cost categories. Derived from (Lemhouer et al. 2020)

In health economic analyses future costs and health outcomes are usually valued less than present costs and health outcomes. Hence, a discount rate of 3.0% for costs and 1.5% for health outcomes was applied, as recommended by the KCE guidelines (Cleemput et al. 2012).



1.6.1.Quality-adjusted life years (QALYs)

The health outcomes are expressed as quality-adjusted life-years (QALYs), which is one of the most commonly used outcome measures in health-economic evaluations. This health outcome combines quality (i.e. HRQoL) and quantity of life (i.e. life expectancy) in one outcome (Drummond et al. 2015; Annemans 2018). As recommended by the Belgian KCE guidelines (Cleemput et al. 2012), the EuroQol Quality-of-Life instrument (EQ-5D), a commonly used generic questionnaire, is used to derive utilities. The utility for all health states was estimated as follows:

- Age and gender-specific utilities were used from a recent publication on the Belgian population norms (Van Wilder et al. 2021), using the newly developed EQ-5D-5L value set for Belgium (Bouckaert et al. 2021).
- Chronic diseases are associated with impaired health-related quality of life (HRQoL) outcomes (Van Wilder et al. 2019). This is taken into account in the model by applying disutilities or utility decrements to the age- and gender-specific utilities. These disutilities are derived from a recent systematic review by Van Wilder et al. (2019), see Table 5.

Table 5. Disutilities related to chronic diseases.

	Year 1	Following years	Original source (via Van Wilder, 2019)
Stroke	0.15	0.19	(Luengo-Fernandez et al. 2013)
CHD	0.16		(Saarni et al. 2006)
Colorectal cancer	0.04		(Sullivan et al. 2011)
Breast cancer	0.09	0.04	(Wood et al. 2017)
Diabetes (T2DM)	0.07		(Redekop et al. 2002)
Depressive disorders	0.18		(Moberg, Alderling, and Meding 2009)

- Physical activity is associated with an increase in QoL, although the evidence appeared to be rather limited (see Part One). A utility increment of 0.006, derived from Choi et al. (2020), is added for the gym alternatives.

QALYs are then calculated by multiplying the utilities with the number of years spent in that particular condition.

As previously mentioned, all outcomes in this analysis are monetarized.[3] **The willingness-to-pay** for a QALY (i.e. one year in perfect health) is considered to be **40 000 €**, based on the gross domestic product (GDP) per capita of Belgium (in 2020: 37 263.45€).

1.6.2. Medical costs

Direct medical costs are costs directly related to the disease or its associated comorbidities (Annemans 2018). These costs are retrieved from the literature, with a focus on to Belgian cost data. When no Belgian data was available, the most recent cost data from international studies was used. All costs were converted (reference year 2020, reference country Belgium), using an online cost convertor (https://eppi.ioe.ac.uk/costconversion/default.aspx).

[3] Results of these type of analyses are often expressed in terms of costs per QALY, in other words without monetarizing QALYs. This sector-specific outcome is sufficient to make comparisons within the healthcare sector. However, the consequences of the global pandemic caused by Covid-19 were not limited to the healthcare sector. In order to allow cross-sector comparisons, it can be beneficial to express all outcomes in monetary terms.

Table 6. Costs related to chronic diseases.

	Converted costs	Original costs	Year, country	Source
Stroke				(Dewilde et al. 2017)
First year	32,243 €	29,239 € (n.r.)	2013; Belgium	
Following years	13,656 €	12,384 € (n.r.)	2013; Belgium	
Coronary heart disease				(Smolderen et al. 2012)
First year	1,414 €	1,122 € (n.r.)	2004; France	
Following years	2,200 €	1,746 € (n.r.)	2004; France	
Colorectal cancer				(Pacolet et al. 2011)
First year	22,477 €	19,034 € (n.r.)	2009; Belgium	
Following years	12,922 €	10,943 € (n.r.)	2009; Belgium	
Breast cancer				(Pacolet et al. 2011)
First year	17,278 €	14,632 € (n.r.)	2009; Belgium	
Following years	9,285 €	7,862 € (n.r.)	2009; Belgium	
Diabetes				(Stegbauer et al. 2020)
All years	5,573 €	4,882€	2015*; Germany	
Depressive disorders				(Wagner et al. 2016)
All years	987 € (3,210 €)	797 € (2,593€)	2010; Germany	

As recommended by the KCE guidelines, possible negative effects of the assessed alternatives should be taken into account (e.g. adverse events). For exercise interventions, the main adverse events are sport injuries. Data on frequency and cost of injuries during gym participation is limited. A Belgian study was identified, that estimated the injury rate and medical costs in sport federations (Cumps et al. 2008). It is likely that this input is an overestimation of the injury rates in gyms, as this study also included several contact sports. Hence, a scenario analysis was performed that excluded these medical costs.

Table 7. Injury rate and costs.

Injury rate	Converted costs	Original costs	Year, country	Source
2.91%	€241.98	€180.48	2003; Belgium	(Cumps et al. 2008)

1.6.3.Productivity

The additional days of sickness absence due to chronic diseases were retrieved in a Dutch observational study (de Vroome et al. 2015), see Table 8.

Table 8. Additional days of sickness for the included chronic diseases.

Disease in model	Additional days of sickness absence	Linked to disease category (de Vroome et al., 2015)
Stroke	12.0	Cardiovascular diseases
Coronary heart disease	12.0	Cardiovascular diseases
Colorectal cancer		
First year	30.3	Life-threatening diseases
Following years	8.0	Other chronic diseases
Breast cancer		
First year	30.3	Life-threatening diseases
Following years	8.0	Other chronic diseases
Diabetes	4.7	Diabetes
Depressive disorders	18.7	Psychological complaints and diseases

To estimate the cost per day, an hourly labour cost in 2020 for Belgium of 41.1€ was retrieved from Eurostat. A work week of 38 hours/week (i.e. 7.6 hours/day) was considered, including an adjustment for holidays, as suggested in the KCE guidelines:

$$\frac{38\frac{hours}{week}}{5\frac{days}{week}} \cdot \frac{\left(52\frac{weeks}{year}\cdot 5\frac{days}{week}\right) - 24\ legal\ and\ extra\ holidays - 10\ public\ holidays}{\left(52\frac{weeks}{year}\cdot 5\frac{days}{week}\right)}$$

$$= 7.6\ hours/day \cdot \frac{226\ days/year}{260\ days/year} = 6.6\ hours/day$$

An average of 6.6 hours per working day was assumed in the base case analysis, which results in a daily labour cost of 271.51€. In addition, a scenario analysis was performed with unadjusted hours per day (i.e. 7.6 x 41.1€ = 312.36€).

1.7. Net monetary benefit

The results are expressed in monetary terms and aggregated in an net monetary benefit (NMB). Net monetary benefit is a recognized summary measure that represents the value of an intervention or health technology (here: physical activity). NMB measures the difference in NMB between alternative interventions, a positive NMB indicates that the “intervention” is cost-effective compared to the alternative at the given willingness-to-pay threshold (€40,000/QALY).

The NMB is calculated as follows:

$$\Delta\ health\ effect\ .\ WTP\ threshold - \Delta costs$$

In our analysis, QALYs are already monetarised (see Section 0), and costs are divided in medical costs and costs due to productivity losses. This results in:

$$\Delta\ monetarized\ QALYs - (\Delta\ medical\ costs + \Delta\ productivity\ costs)$$

To further interpret the results of this model, three comparisons were made:

- The NMB on an individual level can be compared to the membership fee. According to the European Health & Fitness Market Report of 2020 (EuropeActive and Deloitte 2020), the average membership fee in Belgium is 34.7 € per month. For this analysis, we applied a rounded membership fee of 35 €, with a range of 20 € to 50 €. For a time horizon of 15 years, the investment of the gym participants results in an undiscounted cost of 6300 € (35 €/month x 12 months x 15 years), or a discounted cost of 5164 €.

- The NMB on a population level can expressed in function of the number of employees in the Belgian fitness industry. In 2019, there were 3966 employees and 1754 self-employed people in the fitness sector.(4)

- The NMB on a population level can be compared to the expected cost of employment in the fitness sector. In 2019, there was a total of 49 682 673 € wage cost for every employees (excl. self-employed) in the fitness sector. If this is extrapolated to the total number of people employed in the fitness sector (employees and self-employed people), this results in an estimated wage cost of 71 655 293 €. This extrapolation is a simplification, as it does not take into account the differences in labour regulation between self-employed workers and employees.

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[4] This includes both fulltime and parttime employees. Given the available data, it was not possible to derive fulltime equivalents (FTEs).

1.8. Population

This model was focused on gym participants. Demographic data was retrieved from Scheerder et al. (2020) who considered this a cohort with a mean age of 37 years, and 51.4% female. Based on Belgian data from a large fitness chain, other age inputs and gender distributions were tested in additional scenario analyses.

In 2017, 14.6% of the population older than 15 years participated in any fitness activity (Scheerder, Vehmas, and Helsen 2020). When we consider the Belgian 15+ population of 9 574 893, this results in a total cohort of 1 397 934 gym participants.

1.9. Sensitivity analyses

The impact of different assumptions was investigated using scenario analyses. In each of these scenario analyses, one assumption (model or input assumption) is varied at a time, while all other model parameters were held at their base case values. Scenarios included in this analysis are summarized in Table 9.

Table 9. Included scenario analyses.

Parameter	Base case value	Scenario values	Section
Time horizon	15Y	5Y, 10Y, 20Y	1.2
Age	37Y	25Y, 45Y	1.8
% Female	51.4%	35%	1.8
Discounting	3%/1.5%	3%/3%, 5%/5%, 0%/0%	1.6
Short-term QoL gain	0.006	0	1.6.1
Injury rate	2.91%	0	1.6.2
Productivity	6.6 h/day	7.6 h/day	1.6.3
Incidence rates	Recalibration	No recalibration	1.1

In order to evaluate the sensitivity of the model to each input parameter, a one-way sensitivity analysis (OWSA) is also performed. In an OWSA the input value of one parameter is altered whilst holding all other values constant. The relative impact of each parameter on the NMB is presented in a tornado diagram. The most impactful variable (i.e. greatest difference between the NMB obtained with the low and high value inputs) is presented at the top, with the least impactful variable at the bottom. For each parameter, the model calculates the low and high values as a decrease or increase of 10% of the base case value, respectively. This proportional change of 10% is an arbitrary choice, but should be identical for all parameters. By varying all the parameters by the same degree one is able to test the relative sensitivity of the model for each variable. This approach is particularly useful in identifying the key model drivers.

The evolution of the simulation over a time horizon of 15 years is shown in Figure 9.

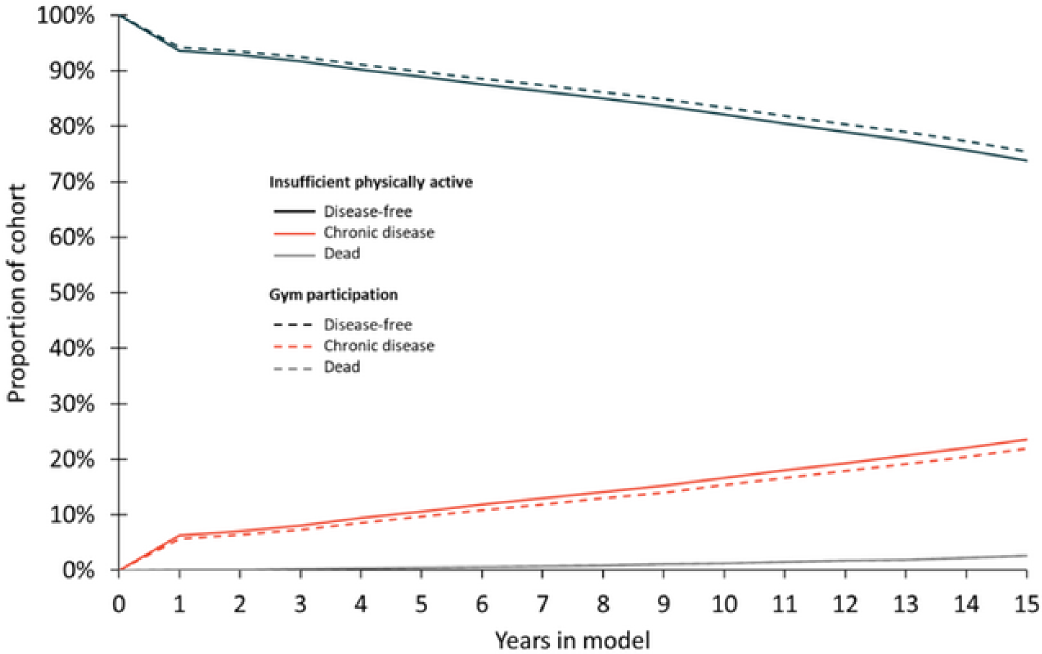

Figure 9. Trace of the simulation, for gym participation (full capacity) vs. insufficient physical activity.

The total estimates per alternative over a 15-year time horizon are provided in Table 10. The incremental base case results over a 15-year time horizon are calculated in Table 11.

Table 10. Absolute base case results, over a 15-year time horizon

	Medical costs	Productivity	QALY
For an individual (n=1)			
Insufficient physical activity *(< 600 MET min/week)*	4 133 €	7 419 €	456 825 €
Gym participation *(900 MET min/week)*	3 980 €	6 776 €	461 151 €
One-year closure	3 996 €	6 853 €	460 788 €
For the estimated population in Belgium that visits the gym (n=1 397 934)			
Insufficient physical activity *(< 600 MET min/week)*	5 777 M €	10 372 M €	638 612 M €
Gym participation *(900 MET min/week)*	5 564 M €	9 473 M €	644 659 M €
One-year closure	5 586 M	9 581 M	644 152 M

M €: million euros.

Table 11. Incremental base case results, over a 15-year time horizon

	Incremental medical costs	Productivity gained	QALY gained	NMB
For an individual (n=1)				
Gym (full capacity) *vs. insufficient physical activity*	-153 €	-643 €	4 326 €	5 121 €
Gym: 1Y- closure *vs. full capacity*	16 €	77 €	-363 €	-456 €
For the estimated population in Belgium that visits the gym (n=1 397 934)				
Gym (full capacity) *vs. insufficient physical activity*	-213 296 391 €	-898 571 680 €	6 046 979 223 €	7 158 847 294 €
Gym: 1Y-closure *vs. full capacity*	22 225 341 €	107 674 306 €	-507 110 930 €	-637 010 576 €

Gym (full capacity) vs. Insufficient physical activity

When gym usage increases physical activity levels with 900 MET minutes/week (i.e. 2.5 hours/week at moderate to vigorous intensity) (see Section 1.5), it has the potential, compared to a less active lifestyle (i.e. <600 MET min/week), to reduce medical costs with 153 €, reduce productivity losses with 643 €, and gain 4 326 € due to increased QALYs per individual. This results in a NMB of 5 121 € over a time period of 15 years. When we extrapolate these results over the estimated no. of gym participants in Belgium (n= 1 397 934), a NMB of 7.2 billion € can be found.

This NMB can be compared with the membership cost over this same time period, see Table 12. With an average membership cost of 35€ per month, this results in an investment cost of 5 164€ (discounted) over a period of 15 years per individual. From the perspective of the individual himself, 84% of his/her investment is recovered in health (i.e. monetarized QALY gains of 4 326 € vs. 5164 € membership costs). Together with the societal savings (i.e. plus medical costs and productivity gains), the entire investment can be recovered (5 121 € NMB vs. 5 164 € membership costs).

Table 12. Net monetary benefit, compared to membership costs, over a 15-year time horizon

	Average	Lower bound	Upper bound
Membership cost/month	**35 €**	20 €	50 €
For an individual (n=1)			
Total membership cost (discounted)	**5 164 €**	2 951 €	7 378 €
Δ NMB *(gym vs. insufficient physical activity)*		**5 121 €**	
For the estimated population in Belgium that visits the gym (n=1 397 934)			
Total membership cost (discounted)	**7 219 423 409 €**	4 125 384 805 €	10 313 462 014 €
Δ NMB *(gym vs. insufficient physical activity)*		**7 158 847 294 €**	

The NMB on population level can also be expressed in function of the number of employed persons in the Belgian fitness industry. If we consider 5720 employed people in the fitness industry, this implies that on average each employee creates a benefit of 1 251 547 €.
Lastly, the NMB on population level can be compared to the wage cost in the fitness sector, see Table 13. Based on the wage cost and number of people employed in the fitness sector (self-employed and employees) in 2019, a yearly wage cost of 71 655 293 € was considered. Over a time horizon of 15 years, this results in a discounted cost of 881 078 720 €. If this cost is subtracted from the NMB on population level, this results in a net return of almost 6.3 billion €, or a return of investment of 7.13.

Table 13. Net monetary benefit, compared to the labour cost, over a 15-year time horizon

Δ NMB (gym vs. insufficient physical activity)	7 158 847 294 €
Labour cost	881 078 720 €
Net return	6 277 768 573 €
Return on investment (net return / investment cost)	7.13

Gym usage: 1Y- closure vs. full capacity

If, over a time horizon of 15 years, physical activity of the gym participants (n=1 397 934) would be reduced to a physically less active level (< 600 MET min/week) for a period of one year, it is estimated that this would lead to 22 million € on additional medical costs, 108 million € on costs related to additional productivity losses, and 507 million € on costs related to additional QoL losses. For the entire population of gym participants, the NMB of keeping gyms open on full capacity vs. being closed for one year (over a period of 15 years) is 637 million €.

2.1. Scenario analyses

The results of the scenario analyses are presented in Figure 10 and Table 14.
The scenarios in which a 5-year time horizon or no short-term health gains due to PA were applied, resulted in the lowest NMBs. The scenarios in which a 20-year or 25-year time horizon or no discounting was applied, resulted in the highest NMBs.

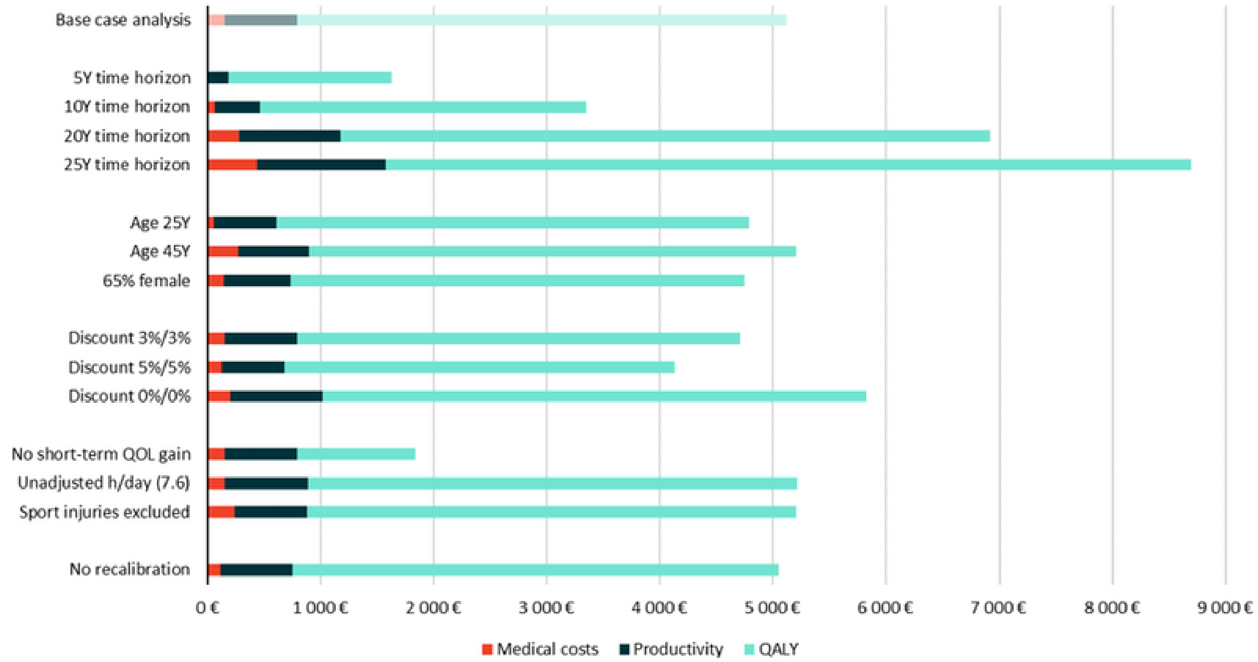

Figure 10. NMBs of the scenario analysis for the comparison gym (full capacity) vs. insufficient physical activity.

Table 14. Results of the scenario analyses. Grey values indicate that the values are identical to the base case analysis.

Parameter	Base case value/setting	Scenario value/setting	Gym (full capacity) vs. insufficient physical activity				Gym: 1 year closure vs. full capacity			
			Δ medical costs	Δ productivity	Δ QALY	Δ NMB	Δ medical costs	Δ productivity	Δ QALY	Δ NMB
Base case			-153 €	-643 €	4 326 €	5 121 €	16 €	77 €	-363 €	-456 €
Time horizon	15Y	5Y	-14 €	-174 €	1 437 €	1 625 €	5 €	46 €	-310 €	-362 €
		10Y	-65 €	-397 €	2 886 €	3 348 €	11 €	63 €	-338 €	-412 €
		20Y	-277 €	-894 €	5 742 €	6 913 €	20 €	88 €	-385 €	-493 €
		25Y	-435 €	-1 140 €	7 126 €	8 702 €	23 €	97 €	-406 €	-526 €
Age	37Y	25Y	-57 €	-554 €	4 179 €	4 789 €	8 €	61 €	-337 €	-407 €
		45Y	-273 €	-624 €	4 306 €	5 203 €	32 €	79 €	-373 €	-485 €
% Female	51.4%	35%	-142 €	-594 €	4 008 €	4 744 €	17 €	81 €	-369 €	-467 €
Discounting	3%/1.5%	3%/3%	-153 €	-643 €	3 911 €	4 707 €	16 €	77 €	-355 €	-448 €
		5%/5%	-127 €	-557 €	3 448 €	4 132 €	14 €	71 €	-347 €	-432 €
		0%/0%	-204 €	-811 €	4 811 €	5 827 €	20 €	88 €	-371 €	-479 €
Short-term QoL gain	0.006	0	-153 €	-643 €	1 044 €	1 840 €	16 €	77 €	-118 €	-211 €
Productivity	6.6 h/day	7.6 h/day	-153 €	-739 €	4 326 €	5 218 €	16 €	89 €	-363 €	-467 €
Incidence rates	Recalibration	No recali-bration	-113 €	-633 €	4 303 €	5 049 €	13 €	76 €	-361 €	-450 €
Injury rate	2.91%	0%	-239 €	-643 €	4 326 €	5 207 €	23 €	77 €	-363 €	-463 €

2.2. One-way sensitivity analysis (OWSA)

An OWSA was performed to assess the impact of estimated parameters on the costs and outcomes associated with both treatments. The tornado diagram below (Figure 11) displays the extent to which the results are affected by a change in the parameters compared to the base case analysis. The length of the bar represents the magnitude of the deviation of each observed NMB observed compared to the base case.

Figure 11 shows that the NMB is mainly influenced by the risk reductions related to increased levels of PA for all diseases, and for some specific diseases, such as depression and T2DM. The probability of recovery for depression and (dis)utilities also appeared to be driving parameters in the model. Through alterations of each parameter by ± 10%, the NMB fluctuates between 3 122 € and 7 151 €.

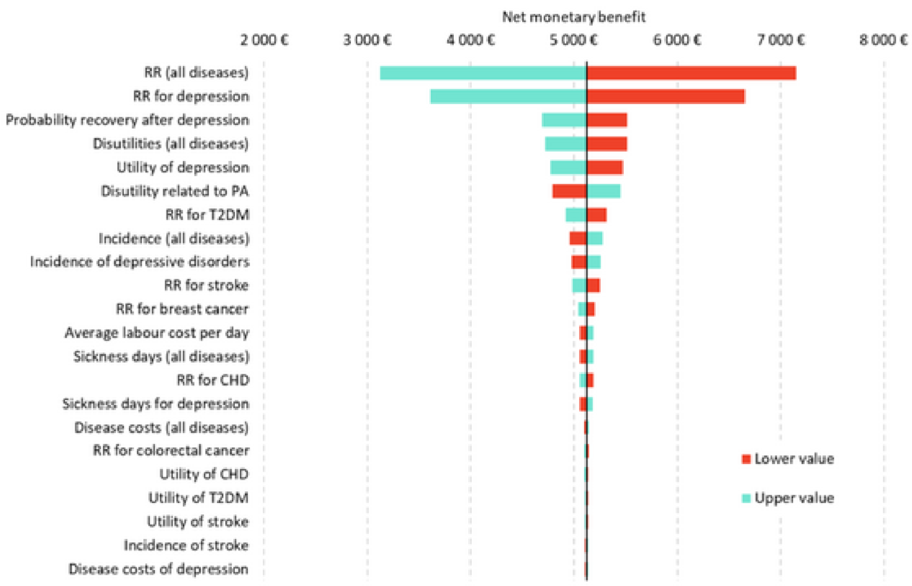

Figure 11. Tornado diagram for gym (full capacity) vs. insufficient physical activity.
(CHD: coronary heart disease; PA: physical activity; RR: relative risk; T2DM: type 2 diabetes mellitus)

3. Discussion and conclusions

Our aim was to estimate the potential health-economic impact of gym usage. An age- and gender-specific Markov model was used to estimate the expected gains or costs related to quality of life, medical costs, and productivity. Six chronic diseases were included in our analysis. Scientific evidence has already established the relation between physical activity, due to gym participation, and a reduced risk to develop one of those aforementioned diseases. Moreover, a short-term QoL gain was added for people who were physically active. It is important to keep in mind that the results are based on indirect evidence, as is often the case in health-economic modelling. In other words, intermediate endpoints (e.g. level of physical activity) are extrapolated to relevant long-term end points (chronic diseases, QALYs, medical costs, and productivity). This so-called causal chain will always induce a degree of uncertainty (Pil 2016). However, this is inherent to health-economic modelling, and is the main reason why several sensitivity analyses are performed. More importantly, health-economic modelling enabled us to estimate effects over a longer period of time, which is highly relevant for healthcare policy.

When an individual visits the gym approximately 2.5 times per week, for 60 minutes per session, at moderate to vigorous intensity, this corresponds with an additional 900 MET min/week. In that case, gym usage has the potential to create a net monetary benefit (NMB) of 5 121 € per individual over a time period of 15 years. Membership costs for a period of 15 years is estimated at 5 164 €, which implies that this is almost fully recovered by the health and economic gains.

Of course, there are other costs that may be related to gym usage. Examples are sportwear, travel costs, and increased costs due to changes in dietary patterns. These costs can be substantial for some people, but large differences can be expected. However, all these costs remain to be borne by the gym member. It can therefore be concluded that the end user pays: gym members invest in their own health, which benefits not only themselves but also the broader society.

In preventive analyses, it is well known that potential gains at individual level remain relatively small (Werbrouck 2021). For example, the 4 326 € gain due to increased QALYs per individual translated back to 0.11 QALYs, or 1.3 “quality-adjusted life month” gained over a period of 15 years. Although this feels negligible on an individual level, a considerable benefit could be achieved on a population level. Extrapolated over the estimated no. of gym participants in Belgium (n = 1 397 934), the NMB of gym usage (i.e. 900 MET min/week) vs. an insufficiently active lifestyle (<600 MET min/week) is estimated at almost 7.2 billion €. More than 6 billion € is achieved in terms of monetarized gained QALYs, which equals to 151 174 QALYs gained.

The NMB of 7.2 billion € can be put in perspective by expressing it in terms of the number of employees in the fitness sector. 5 720 people currently work in this sector, which implies that each employee in the fitness industry creates a benefit of 1.3 million € over a period of 15 years. Compared to the estimated wage cost in the fitness sector for 15 years (discounted), this would result in a net return of 6.3 billion €.

Lastly, a temporary closure is simulated by an insufficiently active lifestyle (< 600 MET min/week) for a period of one year, over a time horizon of 15 years. In that case, the NMB reduces with 456 € per individual or 637 million € for the population of gym participants. Hence, a relatively short closure of gyms appears to have an important health and economic impact.

This model is, as any health-economic model, a simplification of reality, and this is particularly true for the simulation of scenario of temporary closure. From a survey in November 2020 by the Belgian fitness federation, it appeared that 75% of the gym members were less physically active during the closure of the gyms. However, the magnitude of this reduction was not assessed, therefore we were still obliged to make an assumption.

This model is not suited to assess the potential benefits of gym closure on containing the spread of Covid-19. However, it is recommended that the potential benefits of gym participation should be considered and weighted against the potential benefits of a closure in terms of transmission of Covid-19.

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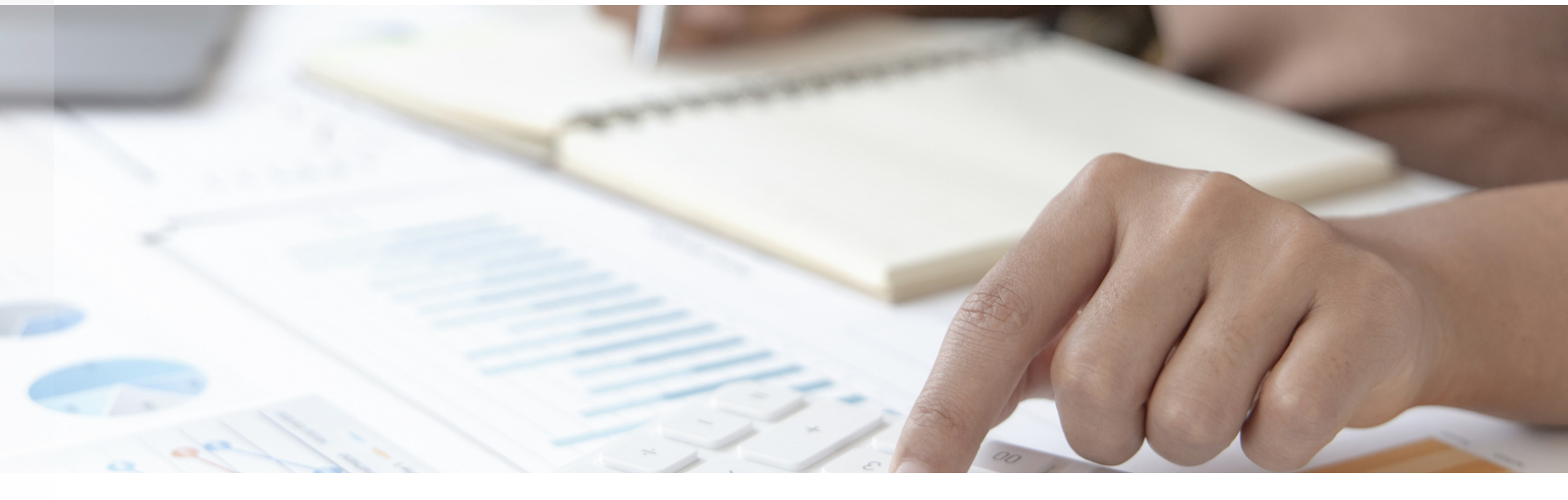

Appendix 1 | Details of the search strategy

An overview of the used search strings and filters and their subsequent results is provided in the table below. The literature search was performed until September 23th 2021. The search results highlighted in light red, indicate the results that were further assessed. Based on title and abstract we selected the relevant papers which are then shown in our evidence tables.

	No filter	Filters			Relevant results?
		SR	< 5y	SR + <5y	
Gym usage & Physical activity					
("Physical Fitness"[Mesh] OR "Exercise"[Mesh]) AND "Metabolic Equivalent"[Mesh]	227	4	110	3	No
("Fitness Centers"[Mesh]) AND "Metabolic Equivalent"[Mesh]	2	0	1	0	No
"Metabolic Equivalent"[Mesh]	330	4	124	3	No
"Metabolic Equivalent"	1,983	38	924	29	Yes
("Fitness Centers"[Mesh]) AND (("Exercise"[Mesh]) OR ("Physical Fitness"[Mesh]))	236	2	78	1	No
"Fitness center"	326	4	138	2	Yes
Physical activity & Chronic diseases					
("Metabolic Equivalent"[Mesh]) AND (("Noncommunicable Diseases"[Mesh]) OR ("Chronic Disease"[Mesh]))	8	0	3	1	Yes
Chronic disease & Quality of life					
((noncommunicable disease[MeSH Terms]) OR (chronic disease[MeSH Terms])) AND (quality of life[MeSH Terms])	9,358	350	2422	179	Yes
(((((Stroke[MeSH Terms]))) OR (depression[MeSH Terms])) OR (depressive disorder[MeSH Terms])) OR (coronary disease[MeSH Terms])) OR (diabetes mellitus, type 2[MeSH Terms])) OR (breast neoplasm[MeSH Terms]) AND (quality of life[MeSH Terms]))))	29,089	1,081	9,657	649 (Adult: 210)	Yes
Chronic disease & Productivity					
(((noncommunicable disease[MeSH Terms]) OR (chronic disease[MeSH Terms])) AND (absenteeism[MeSH Terms]))	428	9	40	4	Yes
((((noncommunicable disease[MeSH Terms]) OR (chronic disease[MeSH Terms])) AND (presenteeism[MeSH Terms])	15	0	10	0	No
Chronic disease & Costs					
(((((noncommunicable disease[MeSH Terms]) OR (chronic disease[MeSH Terms]))) AND (healthcare costs[MeSH Terms])) OR (resource allocation[MeSH Terms])	20,008	120	2,733	58	Yes
(((((((Stroke[MeSH Terms]))) OR (depression[MeSH Terms])) OR (depressive disorder[MeSH Terms])) OR (coronary disease[MeSH Terms])) OR (diabetes mellitus, type 2[MeSH Terms])) OR (breast neoplasm[MeSH Terms]) AND (healthcare costs[MeSH Terms]))	4,305	86	983	43	Yes

Physical activity & Progression					
(((noncommunicable disease[MeSH Terms]) OR (chronic disease[MeSH Terms])) AND ((Disease progression[MeSH Terms]) OR (Progression-free survival[MeSH Terms])) AND (Physical activity[MeSH Terms]))	23	0	9	0	Yes
((Disease progression[MeSH Terms]) OR (Progression-free survival[MeSH Terms])) AND (Physical activity[MeSH Terms]))	1098	33	378	22	No
(((noncommunicable disease[MeSH Terms]) OR (chronic disease[MeSH Terms])) AND ((Disease progression[MeSH Terms]) OR (Progression-free survival[MeSH Terms])) AND (Physical fitness[MeSH Terms]))	23	0	1	0	No
((Disease progression[MeSH Terms]) OR (Progression-free survival[MeSH Terms])) AND (Physical fitness[MeSH Terms]))	114	5	56	3	No
(((noncommunicable disease[MeSH Terms]) OR (chronic disease[MeSH Terms])) AND ((Disease progression[MeSH Terms]) OR (Progression-free survival[MeSH Terms])) AND (Exercise[MeSH Terms]))	23	0	9	0	Yes
(((Stroke[MeSH Terms]) OR (depression[MeSH Terms]) OR (depressive disorder[MeSH Terms]) OR (coronary disease[MeSH Terms]) OR (diabetes mellitus, type 2[MeSH Terms] OR (breast neoplasm[MeSH Terms])) AND ((Disease progression[MeSH Terms]) OR (Progression-free survival[MeSH Terms]) OR (progression)) AND ((Physical activity[MeSH Terms]) OR (Physical fitness[MeSH Terms]) OR (Exercise[MeSH Terms])))	899	32	257	20	Yes
Physical activity & QOL/Well-being					
"Fitness Centers"[Mesh] AND "Quality of Life"[Mesh]	16	0	6	0	No
"Exercise"[Mesh] AND "Quality of Life"[Mesh]	8068	591	4218	437	-
"Exercise"[Majr] AND "Quality of Life"[Majr]) AND "Adult"[Mesh]	1611	52	904	40	Yes
"Exercise"[Mesh] AND (EQ-5D[tiab] OR EQ5D[tiab] OR EQ 5D[tiab] OR euroqol[tiab] OR euro qol[tiab] OR EQ-5D-5L[tiab] OR EQ5D5L[tiab] OR EQ-5D-3L[tiab] OR EQ5D3L[tiab]) AND "Adult"[Mesh]	275	1	178	0	Yes
"Exercise"[Mesh] AND (well-being[ti] OR wellbeing[ti] OR satisfaction[ti] OR "Personal Satisfaction"[Mesh])	1200	39	647	23	Yes

Appendix 2 | Detailed results of the literature search

For each section (i.e. a relation between two building blocks, see Figure 1), a separate evidence table, see page 34 to 47, and a short summary is provided.

Gym usage & Physical activity (Table 15)
To this day, there is only limited evidence available on the effect of gym usage (or gym club membership) on PA. Only one study was identified that investigated the direct relationship between gym club membership, PA, and the corresponding health benefits (Schroeder et al. 2017). The study results indicated that gym club membership was associated with significantly increased PA levels, for both aerobic and resistance PA indicators. Furthermore, more favourable cardiovascular health outcomes were found in members compared to non-members. The study also indicated that the gym club members had significantly less sitting hours/week compared to non-members. However, these results need to be interpreted with caution. Due to the cross-sectional nature of this study, it is impossible to determine causal inference. Two recent cohort studies also showed that gym club members are more physically active compared to the general population (Gjestvang et al. 2019; López Fernández et al. 2021).

King et al. performed a systematic review of the available literature to determine, among other things, the effect of (health plan sponsored) gym club membership on physical activity. However, none of the 5 included studies assessed PA as a primary outcome. Therefore, no conclusions can be made on the association between gym club membership and PA based on the results of this systematic review (King et al. 2012). This review does clearly show that more high-quality research is needed to investigate the effect of gym club membership on PA.

Physical activity & Incidence of chronic diseases (Table 16)
The association between PA and the development of several chronic diseases has been widely studied. This is reflected in the relatively large number of studies that were retrieved in this pragmatic literature search (10 reviews and 1 cohort study).

Several studies conclude that the largest effects of PA (in terms of reduced disease incidence) are observed when moving from inactivity to small amounts of PA (Wahid et al. 2016; Rifai, n.d.; Chen et al. 2019; Franklin et al. 2018; Aune et al. 2016; Kyu et al. 2016). In addition, the current literature also suggests that the total risk reduction PA can offer, continues when moving from low levels of PA towards higher levels of PA (Kyu et al. 2016; Smith et al. 2016). These findings seem to be applicable for different types of chronic diseases (i.e. diabetes type 2 (Kyu et al. 2016; Smith et al. 2016; Al-Mallah, Sakr, and Al-Qunaibet 2018; Wahid et al. 2016; Tarp et al. 2019; Aune et al. 2016), cardiovascular diseases (Kyu et al. 2016; Al-Mallah, Sakr, and Al-Qunaibet 2018; Wahid et al. 2016; Franklin et al. 2018; Rifai, n.d.), and different types of cancer (Kyu et al. 2016; Chen et al. 2019; Neilson et al. 2017; Matthews et al. 2020)).

In conclusion, an increase in PA has an important protective effect since it reduces the incidence of different chronic diseases, both for a sedentary as well as an already physically active population.

Physical activity & Progression of chronic diseases (Table 17)
Four systematic reviews and three cohort studies were identified that assessed the association between PA and progression in chronic diseases.

For people that already acquired one or more chronic diseases, an additional consideration is safety of PA (de Jesus Leite et al. 2020; Albalawi et al. 2017). For example, for people with type 2 diabetes fear of hypoglycemia can be a barrier to implement PA (Albalawi et al. 2017).

The type of prognostic outcome measures largely depends on the disease of interest. For example, for type 2 diabetes, several studies indicated that increased PA is associated with improved glycemic control (Albalawi et al. 2017; Jadhav et al. 2017). However, a Cochrane review found no clear evidence of the effect of PA on glycemic variables (Hemmingsen et al. 2017). In breast cancer, one review carefully concluded that PA could impact the inflammatory process and immune response (de Jesus Leite et al. 2020). In anxiety and depression, there seems to be a bidirectional relationship between PA and specific disease symptoms (Hiles et al. 2017). In other words, greater anxiety and/or depressive symptoms were associated with lower sports participation 2 years later, but lower sport participation was also associated with greater symptom severity 2 years later (Hiles et al. 2017).

Improvements in more general prognostic outcomes such as BMI, exercise capacity, quality of life and well-being were also found across different chronic diseases (Jadhav et al. 2017; Tayer-Shifman et al., n.d.).

The type of PA also plays an important role in chronic disease progression. One study in type 2 diabetesfocused on the type of PA, concluding that a combination of resistance and aerobic training could have the largest impact on disease progression (Albalawi et al. 2017).

Although it is generally accepted that PA should be stimulated in a chronically ill population, the impact of PA on the progression of diseases is still somewhat unclear. This might be explained by the variety in outcome measures to assess chronic disease progression. Furthermore, several authors point out the poor methodological quality of the available evidence, further decreasing the strength of scientific evidence.

Physical activity & Mortality in chronic diseases (Table 18)
A large body of evidence was identified related to the association between PA and mortality in chronic diseases (10 reviews and 5 cohort studies).

PA is associated with reduced mortality risks in numerous chronic diseases such as cardiovascular disease, diabetes, cancer, and heart failure (Warburton and Bredin 2017; Lee et al. 2014). Although the association between PA and mortality is well established, the methodological quality of studies needs to be taken into account when interpreting the scientific evidence for this association. For example, one systematic review reported that studies with higher quality of evidence are associated with smaller reductions in mortality (Posadzki et al. 2020).

Similar to the association between PA and incidence of chronic diseases, there is a large body of evidence suggesting that large risk reductions are already found at low levels of PA (vs. a sedentary lifestyle). Furthermore, the risk reductions also continue at even higher levels of PA (Warburton and Bredin 2017; T. Li et al. 2016; Geidl et al. 2020; Blond et al. 2020; Neilson et al. 2017). It can be concluded that these findings challenge current threshold-based PA guidelines (e.g. the WHO recommends between 150 to 300 minutes of moderate to vigorous physical activity), as each increase in PA – regardless of the previous level of PA – can create health benefits (Warburton et al. 2017).

Chronic diseases & Quality of life (Table 19)
The comparison of quality of life (QoL) outcomes between different disease areas and the general population is of major importance to policy makers, health economists, epidemiologists and clinicians. In this structured literature search we have focused on a specific measure of QoL, namely the EQ5D. This questionnaire is a generic measure of QoL and is frequently used because it is easy to administer and enables us to compare across different disease areas.

Recently, two extensive, international catalogues that describe quality of life in chronic diseases were published (Zhou et al. 2021; Van Wilder et al. 2019). It was concluded that individuals who suffer from chronic diseases have significantly lower levels of QoL, in comparison with the general population (Van Wilder et al. 2019). In addition, the utility value decreases as the disease progresses, and the number of comorbidities and the different types of comorbidities also substantially affect QoL (Zhou et al. 2021).

In conclusion, although the number of identified publications was rather low (2 systematic reviews), the evidence itself is highly relevant. The existence of this catalogue has a huge added value for our health economic model and analysis in the following phase, as it enables us to access the best-available data of EQ5D scores for different chronic diseases.

Chronic diseases & Costs (Table 20)
Three systematic reviews and four cohort studies were identified related to the costs of chronic disease.

It appears that main cost driver(s) depends on the specific condition. For example, in breast cancer the highest cost lies in productivity losses, rather than the direct medical costs (Broekx et al. 2011). In the case of stroke and cardiovascular diseases the main cost drivers consist of the direct medical and hospitalization costs (Caekelbergh et al. 2016). In the case of diabetes costs are largely driven by the occurrence of complications (König et al. 2021).

Moreover, evidence shows that not only are total costs for an individual with a chronic disease higher compared to healthy controls (König et al. 2021), costs also rise depending on the severity of the disease (e.g. stage of disease for breast cancer, or number of complications for diabetes) (Sun et al. 2018). The authors conclude that evidence surrounding the lifetime costs of chronic diseases, describing the full cycle of care, remain scarce.

In conclusion, chronic diseases come at a substantial cost, both for our healthcare system as for society. Although cost seems to rise as disease severity increases, the main cost drivers also depend on the particular disease.

Chronic diseases & Absenteeism (Table 21)
In general, productivity losses can be either due to absenteeism, defined as absence from work (or other duty), or presenteeism, defined as being present but not productive. In this literature search, we focused on absenteeism, keeping in mind that this is only one type of productivity measure.

Two systematic reviews and five cohort studies were identified that assessed absenteeism in chronic diseases.

Based on the Netherlands Working Conditions Survey, a yearly survey on health and work experience, life-threatening diseases (such as cancer or AIDS) and psychological disorders have the highest number of additional days of sickness absence (± 20-30 days/year). Other chronic conditions (such as diabetes or musculoskeletal disorders) correspond with less days of sickness absence (± 7 days/year), but still have a large impact on the total production cost loss due to high prevalence rates (de Vroome et al. 2015).

As mentioned in the previous section, the total costs of productivity loss can be greater than the direct medical costs for some chronic diseases such as breast cancer. Other chronic diseases such as stroke are more difficult to capture, as stroke occurs more frequently in the elderly. Nevertheless, almost 50% of stroke patients reported they were unemployed because of their condition (Lo, Chan, and Flynn 2021).

In conclusion, current evidence shows that the absenteeism costs associated with chronic diseases are substantial and should not be underestimated (Asay et al. 2016; Gordois et al. 2016; van Amelsvoort et al. 2006).

Physical activity & Absenteeism (Table 22)

Although much less examined in comparison with the association between chronic diseases and absenteeism (see supra), the literature also indicates that there is more absenteeism in inactive persons, in comparison to moderately and highly active individuals.

No systematic reviews were identified, but two original studies were included in this literature overview.

A Dutch study based on self-reported company records, found that workers who were active more than once a week, reported significant less sickness absence (van Amelsvoort et al. 2006). In comparison to non-active workers the overall number of days of sickness absence was 19% lower for active workers. This resulted in an average count of 14.8 days of sickness absence versus 19.5 days per year.

A Danish registry showed that the mean duration of sickness absence in a 5-year period was 14.8 weeks for inactive individuals, 11.5 weeks for moderately active and 9.0 weeks for highly active individuals (Høgsbro, Davidsen, and Sørensen 2018). The incidence of long-term sickness absence was also higher in the inactive group.

Physical activity & Quality of life and well-being (Table 23)

Direct effects of PA on numerous physical and physiological outcomes such as oxygen intake, heart frequency, body weight, BMI, muscle strength are well established (Baart de la Faille-Deutekom, Middelkamp, and Steenbergen 2011). In this literature search, we focused on direct effects of PA on quality of life and well-being.

Five systematic reviews and two cohort studies were identified.

Current evidence suggests there is a positive association between the level of PA and QOL (Marquez et al. 2020; Pucci et al. 2012; Choi et al. 2020). One of these studies only found significant positive associations for some types of exercise (vs. no exercise). Depending on the outcome measure, 4 or 5 out of 8 exercise types had a significantly higher QOL than the non-exercise group (Choi et al. 2020).

Regarding well-being, only one systematic review was included, and this review specifically assessed work-place PA interventions. Although the type of interventions can also be performed in a fitness center (i.e. yoga, exercise sessions, and walking sessions), it should be kept in mind that these results might not be transferable. Moreover, results were inconclusive. However, the authors carefully concluded that PA interventions can improve well-being (Abdin et al. 2018). In addition, a cross-sectional study found that light- and vigorous-intensity activity had a positive impact on well-being, while moderate-intensity activity had a negative effect. This led to the conclusion that moderate- and vigorous-intensity should not be used interchangeably (which is now the case in, for example, the WHO PA guidelines) (Wicker and Frick 2016).

In general, it seems that the evidence is not as overwhelming as the abovementioned physical and physiological outcomes. However, the awareness and/or importance of these subjective and/or mental outcomes might be a more recent development in the scientific field. Current evidence suggest that increased levels of PA are associated with better QOL and possibly well-being. However, the intensity of PA should be considered when assessing associations with either QoL or well-being.

Evidence tables

Table 15. Gym usage & Physical activity

Author (year)	Condition	Study design	Key findings	Comments
King et al. (2012)	Healthy	Systematic review (n=5)	Health-plan sponsored fitness center memberships have the potential to increase level of physical activity	Few studies have assessed the impact of health-planned sponsored fitness memberships
Schroeder et al. (2017)	Healthy	Cross-sectional study (n=405)	Health club membership is associated with significantly increased aerobic and resistance PA levels, compared to non-members.	Not possible to infer causal relationship
Gjestvang et al. (2019)	Healthy	Cross-sectional study (n=250)	A higher proportion of gym club members met current PA recommendations, compared to the general adult population in Europe.	Supervised group activities and social support in a safe setting with qualified instructors may aid compliance to physical activity and exercise.
Lopez Fernandez et al. (2021)	Healthy	Cross-sectional study (n=4629)	Leisure centres engage most of their members in regular PA, including women and older adults, and these members perform a higher number of MET in vigorous PA, than the general population.	Differences in PA levels between men and women were confirmed in leisure centres members and the general population.

Table 16. Physical activity & Incidence of chronic diseases

Author (Year)	Condition	Study design	Key findings	Comments
Al-Mallah et al. (2018)	CVD/Diabetes	Review (n=not mentioned)	- Higher CRF is associated with decreased incidence of CVD - ≥12 METs reduced the incidence of diabetes with 54% vs < 6 METs - 1 MET increase in CRF level was associated with 5% lower incidence of diabetes - CRF threshold of 7-8 METs is associated with substantial reduced rate of stroke	
Al Rifai et al. (2019)	Stroke	Retrospective cohort study (n=67.550)	- Graded lower incidence of stroke with higher MET categories - MET ≥ 12: ↓ risk overall stroke (0,42), haemorrhagic stroke (0,71) and ischemic stroke (0,69)	- Study is based on data provided by a single health system, so it may not be generalizable to other populations
Aune et al. (2015)	Type 2 diabetes	Systematic review (n=81)	- PA reduces risk at Type 2 diabetes by 36-41% - Low & high intensity PA showed similar risk reductions	- Greatest relative risk reduction below international PA recommendations - Only included prospective studies
Chen et al. (2018)	Breast cancer	Systematic review (n=45)	- A linear relationship was found between breast cancer risk and PA - The overall relative risk (ORR) was reduced by 3% for every 10 MET h/week increase	- PA measured by self-report - Consistent results across included studies
Franklin et al. (2017)	CVD	Review (n=not mentioned)	- For previously inactive adults, moderate-to-vigorous physical activity, which corresponds to ≥3 METs, may increase MET capacity and decrease the risk of future cardiac events.	
Kyu et al. (2016)	Chronic diseases	Systematic review (n=174)	- The major relative health gains were seen at lower levels of PA with diminishing returns at higher levels of activity - Higher volumes of total PA were associated with reduced risks for breast-, colon cancer, type 2 diabetes, heart disease & ischemic stroke	
Matthews et al. (2019)	Cancer	Systematic review (n=9)	- Engagement in 7,5 -15 MET hours/week was associated with a lower risk in 7 of the 15 cancer types studied - Colon cancer: 8-14% ↓ - Breast cancer: 6-10% ↓ - Additional benefits were seen ≥ 15 MET h/week, depending on cancer type	- Results for moderate-and vigorous intensity PA were mixed - Dose response relationship was linear in half of the studies and non-linear for the others
Neilson et al. (2016)	Breast cancer	Systematic review (n=80)	- Weaker association found between moderate-vigorous recreational activity and breast cancer - Might reflect an overall active lifestyle	- Many trials based on observational data - Only included studies that adjusted for nonrecreational activity
Smith et al. (2016)	Diabetes type 2	Systematic review (n=28)	- 11,25 MET h/week (≈ 150 min/week) is associated with a risk reduction of 26% - 22,5 MET h/week is associated with a risk reduction of 36% - 2,25 MET/week: ↓7% RR -4,5 MET/week: ↓13% RR	-Additional benefits are seen at PA levels greater than current international recommendations
Tarp et al. (2019)	Type 2 diabetes	Systematic review (n=22)	- Each 1 MET higher CRF was associated with an 8% lower relative risk of type 2 diabetes	- A linear dose-response relationship was found
Wahid et al. (2016)	CVD/Diabetes	Systematic review (n=36)	- From inactive to recommended PA levels: 26%↓ incidence diabetes type 2 and a 23%↓ incidence of CVD	

Table 17. Physical activity & Progression of chronic diseases

Author (Year)	Condition	Study design	Key findings	Comments
Albalawi et al. (2017)	Type 2 diabetes	Systematic review (n=23)	- Aerobic exercise and resistance training was associated with improvements in glycaemic control, blood pressure, functional mobility and quality of life - Combined interventions seemed to have a better effect then resistance or aerobic training alone - Exercise was also well tolerated	- Majority of included trials were of poor methodological quality
Aurelio de Jesus Leite et al. (2020)	Breast cancer	Systematic review (n=13)	- Efforts must be applied to avoid physical inactivity - Sedentary behaviour causes damage to physical and mental health, with consequent worsening of the inflammatory profile in the long term	- Safe for most breast cancer survivors - PA complements the benefits of medical treatments
Bennasar-Veny et al. (2020)	Type 2 diabetes	Prospective cohort study (n=234.995)	- The risk for persistence of prediabetes and for progression to T2D increased with age, body mass index (BMI), triglyceride level, and less than 150 min/week of physical activity	- In accordance with these results, previous research also reported reversion from prediabetes to normoglycemia ranged from 20% to 50%
Hemmingsen et al. (2017)	Type 2 diabetes	Systematic review (n=12)	- There is moderate quality evidence that diet plus PA reduces or delays the risk of T2D - There is no clear evidence that diet or PA alone influences the risk of T2D	- Data concerning mortality, complications and health related quality of life are sparse - Included only RCT's
Hiles et al. (2017)	Depression & anxiety	Prospective cohort study (n=2932)	- Greater anxiety or depressive symptoms were associated with lower activity - Low sports participation was associated with greater symptom severity - Low sports participation is associated with increased odds of disorder onset 2 years later	- Mutually reinforcing, bidirectional relationship between psychopathology and lower PA
Jadhav et al. (2017)	Type 2 diabetes	Systematic review (n=19)	- PA intervention showed a favourable effect on improving oral glucose tolerance (RR -0.26, 95% CI -0.06 to 0.07) and fasting blood sugar. (RR -0.05, 95%CI -0.14 to 0.04) - Favourable effect on Glycated hemoglobin (HbA1C), Maximum oxygen uptake and body composition	- PA promotion and participation can help to slow down the progression of disease in individuals with prediabetes
Tayer-Shifman et al. (2018)	Chronic disease population	Retrospective screening of records from the medical fitness facility (n=838)	- A fitness program for patients with multiple chronic diseases is feasible and effective in improving prognostic parameters	- Problems with adherence

Table 18. Physical activity & Mortality in chronic diseases

Author (Year)	Condition	Study design	Key findings	Comments
Warburton et al. (2017)	Mixed	Systematic review (n=16)	- Regular PA: ↓ risk for premature mortality - ↓risk (20-30%) of at least 25 chronic medical conditions	- Health benefits can be accrued at PA levels well below international recommendations
Al-Mallah et al. (2018)	CVD/Diabetes	Review (n=not mentioned)	- Higher CRF is associated with improved survival of CVD (> 10 MET) - Every 1 MET greater level of fitness, 13% reduction in all-cause mortality & 15% reduction in CVD mortality - High levels of evidence of an increase in mortality and cardiovascular mortality with decreased CRF	
Posadzki et al. (2020)		Systematic review (n=150)	Several cochrane SRs who suggest PA ↓mortality rate (13%)	- Evidence for both healthy individuals and medically compromised patients - Underreporting of adherence/withdrawal
Mok et al. (2019)	Sedentary population	Population based cohort study (n=25.639)	- HR all-cause mortality: 0,76 (0,71-0,82) - HR CVD mortality: 0,71 (0,62-0,82) - HR cancer mortality: 0,89 (0,79-0,99)	- At the population level, meeting the health recommendations would potentially prevent 46% if deaths associated with inactivity
Pizot et al. (2016)	Breast cancer	Systematic review (n=38)	-150min/ week : ↓9% lifetime risk - PA associated with RR of 12%	- RR were not affected by type of PA (occupational or non-occupational)
Li Y et al. (2016)	Cancer	Systematic review (n=32)	- 20% decrease in risk of all-cancer mortality among the general population, when comparing highest versus lowest PA - 15% decrease in risk of all-cancer mortality among the general population, when comparing PA versus non/occasional PA	- Prediagnosis PA levels were inversely associated with risk of cancer death
Li T et al. (2016)	Cancer	Systematic review (n=71)	- A minimum of 2.5h/week moderate PA was associated with ↓RR (13-14%) in cancer mortality	- Importance of PA participation after diagnosis stressed
Al-Mallah et al. (2016)	General population	Retrospective registry (n=57.284)	- ↓risk of mortality with ↑MET levels - Already a lower mortality risk < 6 METs - Risk of mortality differed between sexes, women demonstrate lower fitness levels than men by about 2 MET levels, but have a similar prognosis at 2.6 MET levels lower than men	- One of the largest longitudinal studies on the association between PA and mortality
Blond et al. (2019)	General population	Systematic review (n=48)	- Mortality risk was lower at physical activity levels exceeding the recommendations, at least until 5000 MET min/week: all-cause mortality (HR=0.86, 95% CI 0.78 to 0.94) and for CVD mortality (HR=0.73, 95% CI 0.56	- Observational nature of included studies - Inaccurate estimations of amount of PA
Friedenreich et al. (2019)	Cancer	Systematic review (n=136)	- HR of the highest vs lowest level of PA: →Prediagnosis PA for breast cancer 0,82 (0,29-0,75) for colorectal cancer 0,80 (0,74-0,87) →Postdiagnosis PA for breast cancer 0,58(0,52-0,65) and for colorectal cancer 0,63 (0,50 - 0,78)	- Higher pre- and postdiagnosis levels of PA were associated with improved survival outcomes for all cancer - Strongest evidence for breast and colorectal cancer
Geidl et al. (2020)	Chronic disease	Systematic review (n=28)	- 22% ↓ mortality rate in breast cancer - 4% ↓ mortality rate in type 2 diabetes - 12% ↓mortality rate in ischemic heart disease	- Higher levels of post-diagnosis PA are associated with lower mortality rates
Rey-Lopez et al. (2020)	CVD & hypertension	Systematic review (n=8)	- Vigorous intensity PA (vs moderate) was not associated with a larger reduction in mortality (HR 0.95, 95% CI 0.83 to 1.09).	- Does not support the hypothesis that vigorous activity creates larger health benefits on mortality
Martin et al. (2013)	Coronary artery disease	Retrospective study (n=5.641)	- Baseline CRF is highly predictive of long-term mortality in patients with CAD - Higher baseline fitness predicted lower mortality - CRF increase of 1 MET associated with 13% reduction of overall mortality	
Min Lee et al. (2014)	Cancer & CVD	Prospective cohort study (n=1.021)	- Higher levels of PA were associated with lower rates of all-cause and cancer mortality - The current recommendation of 150min/week of moderate-intensity PA was sufficient to lower mortality rates	- Engaging PA after diagnosis is associated with better survival - Only men enrolled with different cancers
Leskinen et al. (2018)	Healthy population	Prospective cohort study (n=42.760)	- On average, vigorously active men and women lived 6.3 years longer in good health and 2.9 years longer without chronic diseases compared to inactive individuals. - The difference in years in good health between vigorously active and inactive individuals was the largest in individuals with low occupation status (6.7 years).	- Focused on population between 50-75 years

Table 19. Chronic disease & Quality of life

Author (Year)	Condition	Study design	Key findings	Comments
Van Wilder et al. (2019)	Chronic diseases	Systematic review (n=207)	- EQ-5D index values ranged between –0.20 and 1 - Lower EQ-5D scores are reported in chronic diseases compared to the general population, specifically in neurological disorders.	- Large number of international studies that included every continent - Heterogeneity in quality of studies - Lack of significance level - Only focused on the EQ5D
Zhou et al. (2021)	Mixed	Systematic review (n=98)	- The health utility ranged from 0.31 to 0.99 for diabetes mellitus - from 0.62 to 0.90 for neoplasms - 0.56 to 0.85 for cardiovascular disease	- Among the 50 different diseases analysed in this review, nearly half of them were only discussed in one study each.

Table 20. Chronic diseases & Costs

Author (Year)	Condition	Study design	Key findings	Comments
Broekx et al. (2009)	Breast cancer	Retrospective cost-of-illness analysis (n=20.439)	- Total average costs of breast cancer amounted to 107,456 € per patient over 6 years. - Total costs consisted of productivity loss costs (89% of costs) and health care costs (11% of costs). - Health care costs of breast cancer patients converged with those of the general population at 5 years following diagnosis.	- Advanced breast cancer stadia had higher health care costs - Direct health care costs were extracted from a claims database, it was not possible to report health care resource use and unit costs separately
Caeckelberghs et al. (2016)	Cardiovascular disease	Retrospective cohort study; conference abstract (n=not mentioned)	- Total costs in the first year for ischemic stroke were €24.640 - In the second year IS costs €7399 - Hospitalization costs were the most important cost driver	- Follow-up costs tended to be higher with increased CVE risk - Analysis based on a health database
Konig et al. (2021)	Type 2 diabetes mellitus	Matched controlled study (n=4.815)	- Total excess costs amounted to €927, of which €719 were attributable to direct and €209 to indirect excess costs. - Total costs were 1.28 higher for T2D compared with controls	- Diabetes complications and comorbidities have a large impact on the costs, more than the disease itself
Li Sun et al. (2018)	Breast cancer	Systematic review (n=20)	- The mean treatment costs of stages II, III and IV breast cancer were 32%, 95%, and 109% higher than those of stage I disease - $29,724 at stage I, $39,322 at stage II, $57,827 at stage III, and $62,108 at stage Iv in 2015 US dollars	- Available data are consistent with earlier detection of breast cancer being associated with lower treatment costs
Rezende et al. (2021)	Colorectal and breast cancer	Cost-of-illness study (n=57,962)	- Direct costs related to colon and breast cancers attributable to lack of PA were Int$ 23.4 million and Int$ 26.9 million, respectively. - Achieving at least the physical activity guidelines would save Int$ 10.3 mi (colon, Int$ 6.4 mi; breast, Int$ 3.9 mi).	- Provides evidence on the health expenditures attributable to a lack of PA
Rochmah et al. (2018)	Stroke	Systematic review (n=13)	In the Netherlands: - the economic loss of stroke equalled €29.484 - Direct medical costs: €18.068,2 - Indirect costs: €15.823,18	- Stroke causes a major disease burden, this justifies the promotion and preventive efforts by policymakers
Stegbauer et al. (2020)	Type 2 diabetes mellitus	Systematic review (n=24)	- The results of this literature review show large differences in reported costs, for example between average annual overall direct healthcare costs (€2793-€32,738 in Germany and €3717-€15,299 in France) - Whereas excess costs seem quite similar (€499–€5724 in Germany vs. €1958–€4051 in France)	-Diabetic complications are the main cost driver

Table 21. Chronic diseases & Absenteeism

Author (Year)	Condition	Study design	Key findings	Comments
De Vroome et al. (2015)	Chronic disease population	National (Dutch) health survey (n=not mentioned)	- Greatest additional days of sickness absence per person were observed for life-threatening diseases (Cancer; 30.0 days), and psychological complaints (19.8 days). - Additional days of sickness absence for any physical (or psychological) disorder in our study ranged between 6.8 and 6.9	- Presenteeism, disability,... were not taken into account
Beeler-Asay et al. (2016)	Chronic disease population	Retrospective cohort study (n=229.615)	- Absenteeism/year for a small employer 6 days and costs were $1,621 for diabetes - A large employer (1,000 employees) could face absenteeism rates of 65 days for diabetes to 1,083 days for physically inactive employees. - Annual costs for a large employer could range from approximately $17,000 for diabetes to more than $285,000 for physical inactivity.	
Fouad et al. (2017)	Workers with chronic disease and without	Retrospective observational study (n=693)	- workers with chronic diseases were more likely to have increased absenteeism and presenteeism rates, 6.34 and 2.36 times the rates if no chronic diseases	
Gordois et al. (2016)	Cardiovascular disease	Systematic review (n=60)	- impact of CVD on physical and mental well-being impairs the ability to work or be productive - Productivity losses & costs associated with CVD.	- The variation in productivity loss estimates arises from differences in study methodology
Lo et al. (2019)	Mixed, of which stroke	Systematic review (n=110)	- In a cohort whose dominant age group was between 60-69 years old, 45.6% stated that they were unemployed as a result of their stroke	- Not many studies investigated work and stroke due to its prevalence in mostly elderly persons
Vuong et al. (2015)	Chronic disease population	Retrospective cohort study (n=80,080)	- Employers lose 28.2 million workdays annually ($4.95 billion in lost income) due to functional limitation caused by chronic diseases - Cancer accounted for the highest average number of workday loss of the seven studied conditions at 37.32 days. - Average numbers of workdays lost for chronic diabetes were 10.43 days	- Based on NHIS data through the Integrated Health Interview Series - This study focused on the link between functional limitations caused by chronic disease among full-time workers
Zhang et al. (2016)	Chronic disease population	Retrospective cohort study (n=28.678)	- Incremental number of absent work days due to health problems in a 3-month period: - Diabetes: 1.53 - Cancer: 1.79 - Heart disease: 1.91 - Mood disorder: 2.25	- Based on a community health survey - Especially mood disorders, back problems and bowel disorders are associated with substantial productivity loss due to absenteeism

Table 22. Physical activity & Absenteeism

Author (Year)	Condition	Study design	Key findings	Comments
Hogsbro et al. (2018)	Workers population (16-54y)	Registry-based study (n=6978)	- Physically inactive individuals had a 27% higher incidence of long-term sickness absence compared with physically active individuals - Longer absence periods for inactive individuals (additional 2.5 weeks) in comparison with moderately and highly active individuals	
Van Amelsvoort et al. (2006)	Workers population	Prospective cohort study (n=8902)	- Workers active in their leisure time twice or more each week reported significantly less sickness absence compared to inactive workers (14.8 versus 19.5 days/year) - Calculating the costs due to lost productive workdays being leisure time inactive was associated with a decreased productivity of €488 per worker per year.	- Possibly, workers' health problems simultaneously reduce the ability of the worker to participate in sports and lead to increased sick leave

Table 23. Physical activity & Quality of life and well-being

Author (year)	Condition	Study design	Key findings	Comments
Pucci et al. (2012)	Mixed	Systematic review (n=38)	- Increased PA is associated with better overall QoL in healthy adults, elderly, and people with chronic diseases. - No agreement of findings in the QoL-domains "social functioning", "bodily pain", and "social relations"	- Not possible to show causal relationships between PA and QoL (because cross-sectional studies) - Mainly use of SF-36 questionnaire for QoL
Choi et al. (2020)	Healthy adults	Cross-sectional study (n=13,437)	- For 4 (EQ-5D index) and 5 (EQ-VAS) out of 8 exercise types, QoL was higher compared to the non-exercise group	- Korean study - different categories of exercise types (i.e. walking, flexibility resistance, and all possible combinations)
Marquez et al. (2020)	Mixed	Systematic review (n=87)	- PA improves QoL in adults aged 18–65 years and older adults (strong evidence) - PA improves QoL in individuals with schizophrenia and Parkinson disease, youth and adults with major clinical depression or bipolar disorder (moderate and limited evidence)	- Strongest evidence exists for elderly and adults - Variation by race, socio economic status, weight, ... are not evaluated due to the lack of information - Lack of agreement across measures of QoL across the included studies
Wicker et al. (2017)	General population (adult)	Cross-sectional study (n=21,008)	- Light-intensity walking and vigorous-intensity activity had a significant positive effect on subjective well-being (i.e. overall life satisfaction) - Moderate-intensity activity had a negative effect	- Self-reported measures
Abdin et al. (2018)	General population (adult)	Systematic review (n=5)	- PA interventions (yoga, exercise sessions, walking) can improve well-being across work-place settings	- Inconclusive evidence - Studies lack depth about behavioural underpinnings (e.g. motivation, intension)
Posadzki et al. (2020)		Systematic review (n=150)	Several cochrane reviews who suggest PA ↑QoL	- Evidence for both healthy individuals and medically compromised patients
Cooney et al. (2013)	Depression	Systematic review (n=37)	- Exercise is moderately more effective than a control intervention for ↓depressive symptoms - Not more effective than antidepressants - Not more effective than psychological therapies	- Many trials used participant self-report

Appendix 3 | Incidence rates

The probability to develop a particular disease in Belgium were derived from incidence rates in the Global Burden of Disease study. A detailed overview of the input that was used in the model is provided in the table below.

Age (years) & gender		Stroke	CHD	Colorectal cancer	Breast cancer	Diabetes	Depressive disorders
15-19	M	0.005%	0.001%	<0.001%	<0.001%	0.346%	2.607%
	F	0.005%	0.001%	<0.001%	0.001%	0.350%	5.019%
20-24	M	0.006%	0.003%	0.001%	<0.001%	0.427%	3.387%
	F	0.007%	0.002%	0.001%	0.002%	0.378%	5.921%
25-29	M	0.009%	0.006%	0.002%	<0.001%	0.163%	3.604%
	F	0.011%	0.002%	0.002%	0.016%	0.089%	5.986%
30-34	M	0.017%	0.022%	0.004%	<0.001%	0.113%	3.990%
	F	0.021%	0.006%	0.004%	0.040%	0.069%	6.516%
35-39	M	0.030%	0.051%	0.007%	<0.001%	0.134%	4.541%
	F	0.038%	0.013%	0.006%	0.065%	0.095%	7.489%
40-44	M	0.055%	0.108%	0.013%	<0.001%	0.279%	4.598%
	F	0.061%	0.028%	0.011%	0.106%	0.190%	7.760%
45-49	M	0.093%	0.194%	0.022%	0.001%	0.540%	4.172%
	F	0.091%	0.052%	0.020%	0.178%	0.349%	7.367%
50-54	M	0.144%	0.335%	0.043%	0.001%	0.808%	3.744%
	F	0.124%	0.090%	0.036%	0.211%	0.537%	6.972%
55-59	M	0.209%	0.532%	0.081%	0.002%	1.066%	3.312%
	F	0.161%	0.144%	0.057%	0.251%	0.743%	6.572%
60-64	M	0.297%	0.758%	0.154%	0.004%	1.006%	3.115%
	F	0.217%	0.245%	0.091%	0.342%	0.790%	6.222%
65-69	M	0.407%	1.015%	0.226%	0.005%	0.703%	3.154%
	F	0.292%	0.393%	0.127%	0.364%	0.703%	5.924%
70-74	M	0.590%	1.333%	0.330%	0.007%	0.813%	3.192%
	F	0.452%	0.634%	0.173%	0.357%	0.875%	5.622%
75-79	M	0.844%	1.712%	0.397%	0.007%	1.254%	3.230%
	F	0.698%	0.968%	0.218%	0.350%	1.250%	5.318%
80-84	M	1.202%	2.305%	0.411%	0.008%	1.044%	3.522%
	F	1.051%	1.409%	0.238%	0.328%	1.028%	5.538%
85-89	M	1.662%	3.110%	0.620%	0.012%	0.354%	4.062%
	F	1.512%	1.955%	0.415%	0.470%	0.353%	6.267%
90-94	M	2.122%	3.966%	0.853%	0.018%	0.022%	4.596%
	F	1.973%	2.771%	0.621%	0.629%	0.027%	6.984%
95+	M	2.582%	4.873%	1.052%	0.022%	0.011%	5.124%
	F	2.434%	3.856%	0.765%	0.822%	0.002%	7.690%

CHD: coronary heart disease; F: female; M: male.