Preventive Medicine Reports 10 (2018) 370–376

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

# Physical activity levels of adults with various physical disabilities

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ARTICLE INFO

*Keywords:*
Physical activity
Disabilities
Health care
Adults

ABSTRACT

This study examined the physical activity (PA) levels of people with specific disabilities, using health care registration data. Data of 321,656 adults (83%) from the Dutch Public Health Monitor 2012 were used to assess adherence to the World Health Organization (WHO) PA guidelines (%) and the time (min/week) spent on moderate-to-vigorous-intensity and vigorous-intensity PA. Specific physical and sensory (i.e. vision and hearing) disabilities were identified by means of two health claims registries that include reimbursement of functional aids and long-term care. Generalized estimated equations were used to determine the association of PA with disabilities, adjusted for confounders (model 1) and additionally for self-reported activity limitations (model 2). Adults with disabilities had lower levels of WHO PA guidelines adherence (range: −49.8% to −11.9%, $p < 0.01$) and of moderate-to-vigorous-intensity PA (range: −691 to −200 min/week, $p < 0.01$) than adults without physical and sensory disabilities. Adults with physical disabilities had the lowest levels. The difference in levels of vigorous-intensity PA between adults with and without physical and sensory disabilities ranged from −12 to 8 min/week Only adults receiving long-term care due to physical disabilities had significantly lower vigorous-intensity PA levels (−12 min/week, $p < 0.01$). After adjustment for self-reported activity limitations, the difference in PA levels between adults with and without physical and sensory disabilities attenuated, especially among those with physical disabilities, but PA levels were still lower for adults with physical disabilities (−34.5% to −9.8% and −466 to −172 min/week, $p < 0.01$, respectively). Regardless of self-reported activity limitations, adults with objectively measured disabilities, especially those with physical disabilities, had lower PA levels compared to adults without physical and sensory disabilities.

## 1. Introduction

Physical activity (PA) has well-known beneficial effects on health, such as a decreased risk of chronic diseases and an improved quality of life (World Health Organization, 2010). Besides these benefits for the general population, PA has also shown health-enhancing effects for people with physical disabilities. Thus it may reduce the risk of chronic diseases and comorbidities, and improve disease-related symptoms, such as high blood pressure and low strength, quality of life and functional status (Bossen et al., 2014; Durstine et al., 2013; Durstine et al., 2000; van der Ploeg et al., 2004).

Recent studies however have shown lower levels of PA among people with physical or sensory disabilities as compared to the general population or people without disabilities (Carroll et al., 2014; Ashe et al., 2009; Kaptein and Badley, 2012; McGuire et al., 2007; von Heijden et al., 2013; Marmeleira et al., 2014). For example, Carroll et al. (2014) reported that the prevalence of physical activity (≥150 min/week of moderate intensity equivalent aerobic activity) among U.S. adults with a hearing impairment, visual impairment or mobility impairment was 45%, 41% and 21%, respectively, which was lower compared to the prevalence among adults without any impairment (54%). Considering the ageing population with a probable increase in the prevalence of physical and sensory disabilities and the concomitant individual and economic burden (van der Ploeg et al., 2004), the promotion of PA among people with physical and sensory disabilities is needed.

Most previous studies examining PA behavior of people with physical and sensory disabilities were based on self-reported data of a selection of health conditions that lead to impairments, e.g. arthritis, or limitations during motor, visual or auditory tasks (Carroll et al., 2014; Ashe et al., 2009; Kaptein and Badley, 2012; McGuire et al., 2007; von Heijden et al., 2013). Impairments (i.e. problems in body function or alterations in body structure) and activity limitations (i.e. difficulties in executing activities) are interconnected areas within the umbrella term disability (World Health Organization, 2011). Another way to indicate impairments is for example the use of assistive devices provided by

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https://doi.org/10.1016/j.pmedr.2018.04.017
Received 18 August 2017; Received in revised form 16 March 2018; Accepted 21 April 2018
Available online 24 April 2018

registrations of health insurance companies. By using objective data of assistive devices, specific information about physical and sensory impairments can be identified more accurately than from self-reported data. However, it is also important to know whether people with a physical or sensory disability experience limitations during activities, since previous studies showed that people with a physical or sensory disability based on objective measures do not necessarily experience limitations or see themselves as being disabled (Iezzoni, 2002). Since activity limitations have a great influence on PA behavior, the estimation of PA levels among people with physical and sensory disabilities needs to account for that. This would contribute to a scientific foundation for policymakers for the design of suitable PA measures for people with physical and sensory disabilities. The aim of this study was to contribute to this scientific foundation using registrations of healthcare institutes and taking into account activity limitations.

## 2. Methods

### 2.1. Study population and design

Data were used from the Dutch Public Health Monitor 2012 (hereafter: Public Health Monitor). The Public Health Monitor is a survey that monitors the health and lifestyle of the Dutch adult population aged 19 years and older living in The Netherlands every four years (RIVM, 2017). A random sample from the Municipal Personal Records Database was selected to participate in the Public Health Monitor in 2012. The response rate was 45–50% and the net sample size of the Public Health Monitor was 387,195 (RIVM, 2017). The Medical Ethics Review Committee of the VU University Amsterdam declared that the approval of the Institutional Review Board (IRB) was not required, because of the minimal impact of the Public Health Monitor on the participants.

To identify people with physical and sensory disabilities, two databases of health care registries were used. First, the “Vektis” database includes health claims from all Dutch health care insurers covered by the Dutch basic statutory insurance package (de Boo, 2011). In this database, 16.7 million insured people living in The Netherlands were included (Nederlandse Zorgautoriteit, 2012), representing 99% of the Dutch population (16.8 million; estimate on January 1, 2013, excluding diplomats, NATO military personnel and people staying illegally in The Netherlands) (Statline, 2013). Vektis data over the period 2009 until 2012 were used. The second health registry database was obtained from the ‘Centre for Care Needs Assessment’ (Dutch: CIZ). This database contains data on the reimbursement of long-term care covered by the Exceptional medical expenses act (Dutch: AWBZ), excluding children under 18 years with mental or psychiatric problems. Data of the year 2012 were used.

Since the two health claims databases included almost the entire Dutch population for which unique citizen service numbers (BSN, a unique registration identifier) were available, data of all participants of the Public Health Monitor 2012, which also includes the BSN, could be linked to the health claims databases on an individual level. In accordance with the Dutch privacy laws and Data Protection Act, the individuals' BSNs were anonymised by replacing the number with a new identification number by a trusted third person, i.e. Statistics Netherlands.

### 2.2. Measures

#### 2.2.1. Physical and sensory disabilities based on assistive devices

In The Netherlands, assistive devices, like a leg prosthesis or white cane can be reimbursed through health insurance companies. Reimbursement is registered in the Vektis database. Two groups of disabilities were selected for this study, i.e. physical disabilities and sensory disabilities. People with physical disabilities used assistive devices like an arm, shoulder and hand prosthesis, a leg- and foot prosthesis, simple mobility aids (e.g. walkers, crutches), and transit chairs. People with sensory disabilities used assistive devices like optical aids, tactile readers, guide dogs, and hearing aids (Appendix A). In addition, the following subgroups were selected: people with a leg or arm prosthesis, people with simple mobility aids (e.g. walkers, crutches), people with mobility aids like reclining and transit chairs, people with visual disabilities and people with hearing disabilities (Table 1). A participant was identified as having a physical or sensory disability if he or she were reimbursed one of the assistive devices during the time period 2009–2012, because assistive devices can be used for a longer period of time before replacement is due. Wheel chair users and deaf people could not be identified in the Vektis database, as wheelchairs are not covered by health insurance (but by the Social Support Act (Dutch: Wmo)), and deaf people do not use hearing aids and may not need long-term care. Hence, these groups could not be explicitly included in the group of people with a physical or hearing disability.

**Table 1**
Prevalence of physical or sensory disabilities based on healthcare registries among the study population ($N$ = 321,656), The Netherlands, 2012.

| | *N* | % |
|---|---|---|
| Physical or sensory disability | 10,553 | 3.3 |
| Based on health profession assessment | 1211 | 0.4 |
| Based on assistive devices | 9563 | 3.0 |
| Physical disability | 4949 | 1.5 |
| Based on health profession assessment | 1041 | 0.3 |
| Based on assistive devices | 4033 | 1.3 |
| Adults with an leg- or arm prosthesis | 106 | 0.0 |
| Adults with simple mobility aids (e.g. walkers, crutches) | 3851 | 1.2 |
| Adults with mobility aids like reclining and transit chairs | 194 | 0.1 |
| Sensory disability | 6634 | 2.1 |
| Based on health profession assessment | 180 | 0.1 |
| Based on assistive devices | 6501 | 2.0 |
| Visual disability | 452 | 0.1 |
| Hearing disability | 6127 | 1.9 |

#### 2.2.2. Physical and sensory disabilities based on health professional assessment

A request for long-term care needs to be filed with CIZ. CIZ assesses the grounds for care eligibility. The assessment is carried out by a professional who diagnoses a condition and determines the associated disorders and impairment. In order to arrive at a “ground” for eligibility, the disorder, impairment and disability are assessed on the basis of ICD-10, DSM-IV-TR and ICF. This leads to a decision as to a person's entitlement to AWBZ care. The following grounds for eligibility were registered in the CIZ database: somatic disorder, psychogeriatric disorder, psychiatric disorder, intellectual disability, psychosocial problem, and physical disability and sensory disability. For the purpose of this study, the latter two were used to identify people with physical disabilities and sensory disabilities (Table 1).

#### 2.2.3. Physical activity

PA was measured with the validated Short QUestionnaire to ASses Health enhancing physical activity (SQUASH) as part of the Public Health Monitor 2012 survey (de Hollander et al., 2012; Wendel-Vos et al., 2003). In SQUASH, participants are asked to report the number of days per week and the average amount of time per day they engage in leisure time activities (e.g. gardening and sports), household activities, activity at work and school, and commuting activities. Based on the compendium of Ainsworth, every activity was given a Metabolic Equivalent (MET)-value (Ainsworth et al., 2011). Moderate-intense activities are operationalized as activities with a MET-value of 3.0–5.9. Vigorous-intense activities are operationalized as activities with a MET-value of ≥6.0 (World Health Organization, 2010).

Three PA variables were calculated based on the frequency and intensity of PA:

**Table 2**
Characteristics of the study population, The Netherlands, 2012.

| | Total ($N$ = 321,656) | Physical or sensory disability ($n$ = 10,553) | No physical or sensory disability[a] ($n$ = 311,103) |
|---|---|---|---|
| Age | 56.2 (17.7) | 73.2 (14.4) | 55.7 (17.6) |
| Sex (% men) | 46.2 | 11.8 | 47.4 |
| Education (%) | | | |
| Low | 42.1 | 76.7 | 41.0 |
| Medium | 29.1 | 15.3 | 29.6 |
| Higher | 28.8 | 8.0 | 29.5 |
| Alcohol (%) | | | |
| Not drinking (0 glasses/week) | 20.4 | 45.0 | 19.5 |
| Light drinking (1–2/1–3 glasses/week) | 25.2 | 23.3 | 25.2 |
| Moderate drinking (3–13/4–20 glasses/week) | 46.0 | 27.7 | 46.7 |
| Excessive drinking (≥14/≥21 glasses/week) | 8.4 | 4.0 | 8.6 |
| Self-reported activity limitations (% yes) | 16.5 | 63.0 | 15.0 |
| Physical activity | | | |
| Moderate-to-vigorous-intensity activities (minutes per week) | 1035 (951) | 473 (663) | 1054 (953) |
| Vigorous-intensity activities (minutes per week) | 50 (143) | 15 (72) | 52 (144) |
| Adherence to the WHO PA guidelines (%) | 90.1 | 60.1 | 91.1 |

[a] Differences between persons with and without disabilities were all statistically significant: $p < 0.001$.

- Adherence to the World Health Organization (WHO) PA guidelines to enhance health and fitness (spending ≥150 min/week on moderate-intensity activities and/or spending ≥75 min/week on vigorous-intensity activities),
- Time (min/week) spent on moderate- to vigorous-intensity activities, and
- Time (min/week) spent on vigorous-intensity activities.

#### 2.2.4. Covariates

Demographic (i.e. age, gender, ethnicity, education), lifestyle factors (i.e. smoking and alcohol), body mass index, and perceived physical disabilities were all, except for age and gender, measured by the Public Health Monitor 2012 survey. Age and gender were obtained from the municipal administration personal data. These factors were tested for confounding by using a stepwise approach and the criterion of a minimum change of 10% in the parameter estimate. Confounders were age, gender, education, alcohol and self-reported activity limitations.

The level of completed education was categorized into lower, medium, and higher education. Alcohol use was categorized as no alcohol use (0 glass/week), light alcohol use (1–3 glasses/week for males and 1–2 glasses/week for females), moderate alcohol use (4–20 glasses/week for males and 3–13 glasses/week for females) and excessive alcohol use (≥21 glasses/week for males and ≥14 glasses/week for females).

Self-reported activity limitation was assessed by seven questions, derived from the Organization for Economic Cooperation and Development Long-Term Disability Questionnaire (Gignac et al., 2011) asking about the limitations in daily life with regard to motor (3 questions), visual (2 questions) and hearing (2 questions) activities. Answers to these questions were given on a 4-point Likert scale: 1) yes, without difficulty; 2) yes, with some difficulty; 3) yes, with much difficulty; and 4) no, I cannot do this. Those who answered at least once "yes, with much difficulty" or "no, I cannot do this" on one of the seven questions were considered as having moderate to severe activity limitation. For the subgroups of activity limitations, the same applied, i.e. if one of the two or three items was rated in category 3 or 4, they were considered as having a visual, hearing, or motor limitation. Every other person was identified as having no self-reported activity limitations.

### 2.3. Statistical analysis

Descriptive analyses were performed to describe the main characteristics of the study population (mean, SD and percentages).

To examine the association of physical and sensory disabilities with PA, generalized estimated equations (GEE) were used. Robust standard errors were used in the analyses of minutes per week spent on PA to account for a skewed distribution. The dependent variables in the analysis were physical and sensory disabilities and the specific subgroups of disabilities. In all analyses, the reference group included people without physical or sensory disabilities based on either assistive devices or health professional assessment. All analyses were adjusted for age, gender, education, alcohol use (model 1) and additionally adjusted for self-reported limitations during motor, visual or hearing activities (model 2). Analyses were performed using SAS Statistical Software, version 9.4.

## 3. Results

### 3.1. Study population

For the present study, complete data of 321,656 participants (83% of the total data from the Public Health monitor and both healthcare registries) were used in the analyses. Three percent of the population (3.3%) had a physical or sensory disability based on healthcare registries, 1.5% had a physical disability and 2.1% had a sensory disability (Table 1).

The mean age of the study population was 56.2 (SD: 17.7) years. Adults with a physical or sensory disability were 17.5 years older and less often male (11.6% vs. 47.4%) and had more often a low education (76.7% vs 41.0%) compared to those without a physical or sensory disability ($p < 0.01$). Adults with a physical or sensory disability drank less alcohol than those without a physical or sensory disability (e.g. not drinking: 45.0% vs 19.5%, $p < 0.01$) (Table 2). Adults with a physical or sensory disability based on health professional assessment and assistive devices reported more often an activity limitation than people without a physical or sensory disability (63.0% vs 15.0%, $p < 0.01$) (Table 2). All three PA measures showed lower levels among adults with a physical or sensory disability than among adults without a physical or sensory disability. For example, adults with a physical or sensory disability spent far less than half the time on moderate-to-vigorous-intensity PA (473 min/week) compared to adults without a physical or sensory disability (1054 min/week) (Table 2).

### 3.2. Physical or sensory disabled adhered less to the WHO guidelines than non-disabled

In model 1, 91% of the adults without a physical or sensory disability (i.e. reference group) adhered to the WHO PA guidelines. In model 2, the adherence of the reference group ranged from 79% to 87%

**Table 3**
Adjusted[c] absolute difference in adherence (%) to the WHO PA guidelines per type of physical or sensory disability compared to no physical or sensory disability, The Netherlands, 2012.

| | Model 1 | | Model 2 | |
|---|---|---|---|---|
| | Reference group[b] (%) | Δ%[a] | Reference group[b] (%) | Δ%[a] |
| Physical or sensory disabilities | 90.5 | −22.1 (−22.7: −21.5) | 83.8 | −15.5 (−16.0: −14.9) |
| Based on health professional assessment | 90.7 | −46.3 (−47.8: −44.7) | 84.2 | −34.5 (−36.0: −33.0) |
| Based on assistive devices | 90.5 | −19.6 (−20.2: −19.0) | 83.8 | −13.6 (−14.2: −13.0) |
| Physical disabilities[1] | 90.6 | −37.7 (−38.5: −36.9) | 79.0 | −21.9 (−22.7: −21.1) |
| Based on health professional assessment[1] | 90.7 | −48.4 (−50.1: −46.7) | 79.0 | −30.1 (−31.7: −28.4) |
| Based on assistive devices[1] | 90.6 | −35.3 (−36.2: −34.4) | 79.0 | −20.1 (−20.9: −19.2) |
| Adults with a leg or arm prosthesis[1] | 90.7 | −21.5 (−26.7: −16.2) | 79.0 | −10.2 (−15.2: −5.2) |
| Adults with simple mobility aids (e.g. walkers, crutches)[1] | 90.6 | −35.4 (−36.3: −34.5) | 79.0 | −20.1 (−21.0: −19.2) |
| Adults with mobility aids like reclining and transit chairs[1] | 90.7 | −49.8 (−53.7: −45.9) | 79.0 | −29.0 (−32.7: −25.3) |
| Sensory disabilities[2] | 90.6 | −13.0 (−13.7: −12.3) | 86.5 | −10.8 (−11.5: −10.1) |
| Based on health professional assessment[2] | 90.7 | −33.3 (−37.4: −29.3) | 86.7 | −25.6 (−29.6: −21.5) |
| Based on assistive devices[2] | 90.6 | −12.6 (−13.3: −11.9) | 86.5 | −10.6 (−11.3: −9.9) |
| Visual disabilities[3] | 90.7 | −26.7 (−29.3: −24.2) | 86.2 | −20.3 (−22.9: −17.8) |
| Hearing disabilities[4] | 90.6 | −11.9 (−12.6: −11.2) | 85.2 | −9.8 (−10.5: −9.1) |

[a] Differences (Δ%) were all statistically significant: $p < 0.001$.

[b] Because each type of physical or sensory disability was modelled separately, the adherence to the WHO PA guidelines of the reference group slightly differed per analysis.

Model 1: Adjusted for age, sex, education, alcohol use.

Model 2: Model 1 + self-reported activity limitation[c].

[c] For the specific disabilities these adjustments were made for [1]self-reported motor limitations; [2]self-reported sensory limitations; [3]self-reported visual limitations; and [4]self-reported hearing limitations.

depending on the type of disability under study (Table 3). Compared to the reference group, adults with a disability adhered less often to the WHO PA guidelines (model 1: −22.1%, $p < 0.001$). The difference in adherence to the WHO guidelines for adults with a physical or sensory disability based on assistive devices compared to the reference group was −19.6% (model 1) and based on health professional assessment −46.3% (model 1). Additional adjustment for self-reported activity limitations attenuated the difference of adherence to the WHO PA guideline between adults with a physical or sensory disability and the reference group (model 2, total: −22.1%; assistive devices: −13.6%; and health professional assessment: −34.5%, $p < 0.001$) (Table 3).

Adults with a physical disability adhered less to the WHO PA guidelines than the reference group (model 1: −37.7%). Among those with physical disabilities, the largest differences were found for adults with a physical disability based on health professional assessment (model 1: −48.4%) and adults with mobility aids like reclining and transit chairs based on assistive devices (model 1: −49.8%). Additional adjustment for self-reported motor limitations (model 2) attenuated the difference between adults with a (specific) physical disability and the reference groups, i.e. −21.9%, −30.1%, and −29.0%, respectively ($p < 0.001$) (Table 3).

Adults with a sensory disability also showed lower adherence to the WHO PA guidelines compared to the reference group (model 1: −13.0%, model 2: −10.8%). Adults with a visual disability and those with a hearing disability based on assistive devices also adhered less often to the WHO PA guidelines (−26.7% and −11.9%, respectively, $p < 0.001$ in model 1). Additional adjustment for self-reported visual limitations altered the difference in PA levels of adults with visual disability compared to the reference group (model 2: −20.3%, $p < 0.001$) (Table 3).

### 3.3. Physical or sensory disabled spent less time on moderate-to-vigorous-intensity PA than non-disabled

Adults without a physical or sensory disability (reference group) spent 1049 to 1054 min per week on moderate-to-vigorous-intensity PA in model 1 and 856 to 1006 min per week in model 2 depending on the type of disability under study (Table 4).

Adjustment for self-reported activity limitations attenuated the association between physical or sensory disability and moderate-to-vigorous-intensity PA. In model 1, adults with a physical or sensory disability spent 331 min per week less on moderate-to-vigorous-intensity PA than the reference group, whereas in model 2 the difference was −228 min per week ($p < 0.001$).For physical or sensory disabilities based on health professional assessment, the differences were −655 min per week and −466 min per week in model 1 and 2, respectively and for physical or sensory disabilities based on assistive devices −295 min per week and −202 min per week, respectively ($p < 0.001$).

Compared to the reference group, the largest negative difference in time spent on moderate-to-vigorous-intensity PA was found in adults with a physical disability (−519 min/week, $p < 0.001$), specifically in adults with a physical disability based on health professional assessment (model 1: −689 min/week) and adults with mobility aids like reclining and transit chairs (model 1: −691 min/week). These differences were attenuated after adjustment for self-reported motor limitations −255 min/week, −379 min/week, −338 min/week, but they were still significant ($p < 0.001$) (Table 4).

### 3.4. Physical or sensory disabled spent more time on vigorous-intensity PA than non-disabled

Adults without a physical or sensory disability (reference group) spent 51 to 52 min per week on vigorous-intensity PA in model 1 and 45 to 48 min per week in model 2 depending on the type of disability under study (Table 5).

Adults with a physical or sensory disability spent more time on vigorous-intensity PA than the reference group (model 1: +4, model 2: +8, $p < 0.001$) (Table 5). More specifically, adults with sensory disability and adults with simple mobility aids spent more time on vigorous-intensity PA than the reference group in both models (model 1: +7 min/week and +4 min/week, respectively; model 2: +9 min/week and +12 min/week, respectively, $p < 0.001$) (Table 5).

Only adults with a physical disability based on health professional assessment (model 1: −12 min/week, $p < 0.001$) and adults with mobility aids like reclining and transit chairs (model 1: −7, $p = 0.05$) spent less time on vigorous-intensity PA. However, after adjustment for self-reported motor limitations, these associations were no longer

**Table 4**
Adjusted[c] absolute difference in minutes per week spent on moderate-to-vigorous-intensity PA per type of physical or sensory disability compared to no physical or sensory disability, The Netherlands, 2012.

| | Model 1 | | Model 2 | |
|---|---|---|---|---|
| | Reference group[b] (min/week) | Δ min/week[a] | Reference group[b] (min/week) | Δ min/week[a] |
| Physical or sensory disabilities | 1049 | −331 (−344: −318) | 944 | −228 (−241: −215) |
| Based on health professional assessment | 1054 | −655 (−686: −624) | 949 | −466 (−498: −435) |
| Based on assistive devices | 1049 | −295 (−309: −281) | 945 | −202 (−215: −188) |
| Physical disabilities[1] | 1052 | −519 (−533: −505) | 857 | −255 (−269: −240) |
| Based on health professional assessment [1] | 1054 | −689 (−720: −658) | 856 | −379 (−409: −349) |
| Based on assistive devices[1] | 1052 | −478 (−493: −463) | 857 | −223 (−239: −207) |
| Adults with a leg or arm prosthesis[1] | 1054 | −428 (−559: −296) | 856 | −237 (−363: −110) |
| Adults with simple mobility aids (e.g. walkers, crutches)[1] | 1052 | −475 (−491: −460) | 857 | −220 (−235: −204) |
| Adults with mobility aids like reclining and transit chairs[1] | 1054 | −691 (−737: −644) | 856 | −338 (−382: −294) |
| Sensory disabilities[2] | 1051 | −215 (−232: −198) | 1002 | −190 (−207: −173) |
| Based on health professional assessment[2] | 1054 | −461 (−567: −356) | 1006 | −367 (−473: −261) |
| Based on assistive devices[2] | 1051 | −209 (−227: −192) | 1003 | −186 (−203: −169) |
| Visual disabilities[3] | 1054 | −368 (−423: −314) | 1006 | −298 (−354: −243) |
| Hearing disabilities[4] | 1051 | −200 (−218: −183) | 977 | −172 (−190: −154) |

[a] Differences (Δmin/week) were all statistically significant: $p < 0.001$.
[b] Because each type of physical disability was modelled separately, time spent on moderate-to-vigorous-intensity PA of the reference group slightly differed per analysis.
Model 1: Adjusted for age, sex, education, alcohol use.
Model 2: Model 1 + self-reported activity limitation[c].
[c] For the specific disabilities these adjustments were made for [1]self-reported motor limitations; [2]self-reported sensory limitations; [3]self-reported visual limitations; and [4]self-reported hearing limitations.

significant (model 2: −2 min/week, $p = 0.31$ and +4 min/week, $p = 0.26$, respectively) (Table 5).

## 4. Discussion

In this study, adults of 19 years and older with a physical or sensory disability were less physically active compared to those without a physical or sensory disability, especially adults with a physical disability based on health professional assessment and those with mobility aids like reclining and transit chairs. However, for vigorous-intensity PA, small but significant higher levels were observed in those with a physical or sensory disability. Our findings further showed an influence of self-reported activity limitations in which the association between objective physical and sensory disabilities and PA was attenuated (though still significant), especially with regard to physical disabilities.

Our findings as to lower adherence to PA levels among people with physical disabilities are in line with previous studies that were based on self-reported physical disabilities (Carroll et al., 2014; McGuire et al., 2007; von Heijden et al., 2013). A study examining specific chronic diseases that lead to motor limitations found that elderly aged 65 years and older with musculoskeletal disease, neurodegenerative disease and stroke had lower PA levels than those without chronic diseases (Ashe et al., 2009). Another study by Kaptein and Badley (2012) among adults aged 18 years and older with arthritis and back problems did not show consistently lower PA levels compared to those with no chronic physical condition. The difference between our findings and the findings by

**Table 5**
Adjusted[b] absolute difference in minutes per week spent on vigorous-intensity PA per type of physical or sensory disability compared to no physical or sensory disability, The Netherlands, 2012.

| | Model 1 | | | Model 2 | | |
|---|---|---|---|---|---|---|
| | Reference group[a] (min/week) | Δ Min/week | *p* | Reference group[a] (min/week) | Δ Min/week | *p* |
| Physical or sensory disabilities | 51 | 4 (2:5) | < 0.001 | 46 | 8 (7:10) | < 0.001 |
| based on health professional assessment | 51 | −10 (−14: −6) | < 0.001 | 47 | −1 (−6:3) | 0.51 |
| based on assistive devices | 51 | 5 (4:7) | < 0.001 | 46 | 9 (8:11) | < 0.001 |
| Physical disabilities[1] | 51 | 1 (−1:2) | 0.46 | 45 | 9 (7:10) | < 0.001 |
| based on health professional assessment[1] | 51 | −12 (−16: −7) | < 0.001 | 45 | −2 (−7:2) | 0.31 |
| based on assistive devices[1] | 51 | 4 (2:5) | < 0.001 | 45 | 12 (10:13) | < 0.001 |
| Adults with a leg or arm prosthesis[1] | 52 | −15 (−36:5) | 0.15 | 45 | −9 (−30:12) | 0.39 |
| Adults with simple mobility aids (e.g. walkers, crutches)[1] | 51 | 5 (3:6) | < 0.001 | 45 | 13 (11:14) | < 0.001 |
| Adults with mobility aids like reclining and transit chairs[1] | 52 | −7 (−14:0) | 0.05 | 45 | 4 (−3:11) | 0.26 |
| Sensory disabilities[2] | 51 | 7 (5:9) | < 0.001 | 47 | 9 (7:11) | < 0.001 |
| based on health professional assessment[2] | 52 | −1 (−9:7) | 0.85 | 47 | 7 (−1:16) | 0.08 |
| based on assistive devices[2] | 51 | 7 (5:9) | < 0.001 | 47 | 9 (7:11) | < 0.001 |
| Visual disabilities[3] | 51 | 5 (−2:11) | 0.15 | 48 | 9 (3:16) | 0.004 |
| Hearing disabilities[4] | 51 | 8 (5:10) | < 0.001 | 46 | 10 (7:12) | < 0.001 |

[a] Because each type of physical disability was modelled separately, time spent on vigorous-intensity PA of the reference group slightly differed per analysis.
Model 1: Adjusted for age, sex, education, alcohol use.
Model 2: Model 1 + self-reported activity limitation[b].
[b] For the specific disabilities these adjustments were made for [1]self-reported motor limitations; [2]self-reported sensory limitations; [3]self-reported visual limitations; and [4]self-reported hearing limitations.

Kaptein and Badley (2012) may be due to the definition of physical disabilities. It is plausible that our population with a physical disability based on the use of mobility aids had more severe limitations than those with (self-reported) back problems or arthritis. The finding that especially people with physical disabilities showed lower PA levels may not be surprising, as PA requires good physical functioning. Although there are organisations that provide adaptive sports specifically for people with physical disabilities, this population may still experience barriers to exercise, or there may be a lack of such facilities in their neighbourhood. Previous studies have shown that for instance shame, pain, inadequate transportation, inaccessible accommodations, inappropriate sports offer without suitable guidance may pose barriers (Bragaru et al., 2013; Jaarsma et al., 2014a).

We further found that people with sensory disabilities had lower adherence to the WHO PA guidelines and lower levels of moderate-to-vigorous-intensity PA compared to those without a physical or sensory disability. This result confirmed findings by previous studies into PA levels among people with visual disabilities (Carroll et al., 2014; von Heijden et al., 2013). These lower levels may be explained by reported barriers to exercise, like orientation problems, poor accessibility of the built environment, inadequate public transport and accommodations, lack of proper PA programmes (and it sustainability) and of trainers or guidance (Phoenix et al., 2015; Jaarsma et al., 2014b). Previous studies into PA and hearing disabilities were not consistent in this respect. In line with our findings, another Dutch study also showed lower PA levels among people with self-reported hearing disabilities compared to those without a disabilities (von Heijden et al., 2013), whereas Carroll et al. (2014) found no differences. Factors like study design, definitions of the disability and PA, and the age of the study populations differed between the studies and may contribute to the mixed findings. An explanation for our findings might lie in barriers like communication problems (with team players, or trainers), lack of alternatives to audible signals, and limited offer of “inclusive” sports (Rankin, 2012). Moreover, exploratory domain-specific analyses showed that people with physical or sensory disabilities had significantly lower PA levels on all domains compared to people without physical and sensory disabilities, except for PA at work. The largest negative difference was found for leisure-time activities (i.e. walking, cycling, gardening, odd jobs and sports). Walking and cycling contributed the most to the lower leisure-time PA levels (data not shown). This emphasizes the need to eliminate barriers in the (near) environment and barriers that are related to sports offer as reported by the literature in order to increase PA.

The higher level of vigorous-intensity PA ($\geq$6.0 MET) in people with physical or sensory disabilities compared to those without physical or sensory disabilities was unexpected (Ashe et al., 2009). Exploratory analyses revealed that age could be an explanation for this unexpected finding, as younger people more often participate in vigorous intense PA and the reference group is younger than those with a physical disability. When stratifying our analysis for age ($<$ 65 years vs. $\geq$65 years) and selecting those who were vigorous intense physically active (min/week $>$ 0), it was indeed confirmed that lower levels of vigorous-intensity PA were generally found for adults with physical disabilities (data not shown).

A clear consistent finding was the influence of self-reported activity limitations for people with physical disabilities and visual disabilities. Adjustment for this variable consistently attenuated the association between the objective physical or sensory disability and PA, especially among people with physical disabilities. Hence, PA strategies should not only be tailored to the objective physical or sensory disabilities, but they should also account for self-reported activity limitations.

### 4.1. Strengths and limitations

Using a large survey including over 380.000 adults enriched with objective and detailed data to identify physical and sensory disabilities and the ability to adjust for self-reported activity limitations (often used as an indicator for disability) are the main strengths of the present study. Objective registration data of physical and sensory disabilities provided us with a more valid and specific identification of physical and sensory disabilities than self-reported disabilities would have. The results clearly showed that objective and self-reported physical and sensory disabilities are two different measures and complement each other. The combined use of objective and self-reported physical and sensory disabilities enabled us to provide insight into specific physical and sensory disabilities while accounting for the limitations of the disability.

Despite the large sample size and the way of sampling, it may be that the Public Health Monitor is not fully representative for the Dutch adult population due to a selective response. More women than men participated in the monitor, as did more native people than foreign people, and more people with a high income than people with a low income (van den Brink et al., 2017). Moreover, people with missing data (17%) more often had physical or sensory disabilities and were less physically active compared to the total number of included participants (data not shown). With regard to the representativeness of the group of people with physical or sensory disabilities, people in wheel chairs may not have been included in the group of people with physical disabilities since wheel chairs are not reimbursed by the health insurance, but are covered by the Social Support Act, which as yet does not have a registry database. Perhaps, it is quite likely that part of the people with wheel chairs was included in the group of people who received long-term care because of their physical disability, but the registries did not allow their identification. In addition, since deaf people do not use hearing aids and do not necessarily get long-term care, they were probably not included in the group of people with a hearing disability. This may have biased our results. The cross-sectional design of the study hampers making any inferences regarding the causal pathway between PA and physical or sensory disabilities. For future research, longitudinal studies are needed to provide insight into the direction of the relation. In addition, research into the needs, barriers, and possibilities is recommended to design and implement health-enhancing-physical-activity programs for this important group of people.

## 5. Conclusion

In this study, adults aged 19 years and older with physical or sensory disabilities were less physically active than people without a physical or sensory disability, especially those with physical disabilities. As self-reported activity limitations had a major impact on this association, it should be considered when designing PA strategies for people with physical or sensory disabilities.

## Author contributions

de Hollander had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design*: All authors; *Acquisition, analysis, or interpretation of data*: All authors; *Drafting of the manuscript*: All authors; *Critical revision of the manuscript for important intellectual content*: Proper; *Statistical analysis*: de Hollander and Proper; *Study supervision*: Proper.

## Funding and conflicts of interest

This study was supported by funds of the Dutch Ministry of Health, Welfare and Sport. The Ministry of Health, Welfare and Sport had no role in study design; collection, analysis, and interpretation of data; writing of the report; or the decision to submit the manuscript for publication.

No conflicts of interest were reported by the authors.

No financial disclosures were reported by the authors of this paper.

## Acknowledgments

We are grateful to the Community Health Services and Statistics Netherlands for making the data from the Dutch Public Health Monitor of the Community Health Services, Statistics Netherlands and the National Institute for Public Health and the Environment 2012 available.

## Appendix A. List of selected assistive devices to identify people with a physical or sensory disability

### *A.1. Physical disability*

Leg- or arm prosthesis

- Arm, shoulder and hand prosthesis
- Leg- and foot prosthesis

Simple mobility aids

- Simple mobility aids – not specified
- Crutches
- Walking aids with three or more legs
- Walking frames
- Rollator walkers
- Service trolleys
- Trolley tables

Adults with mobility aids like transit chairs

- Walking bicycles and chairs on wheels for indoor use (e.g. transit chair)

### *A.2. Visual disability*

- Electronic magnifiers
- Magnifiers with light
- Magnifiers without light
- Binoculars and telescope glasses
- White canes
- Guide dogs
- Costs of guide dogs
- Tactile reading devices

Glasses or contact lenses are not included, since they are not covered by the basic statutory insurance package.

### *A.3. Hearing disability*

- In-the-ear hearing aids
- Behind the ear hearing aids
- Hearing glasses
- Other hearing aids, not specified
- Hearing aids for tinnitus relief
- Induction loops
- FM system
- Infrared system
- Earpieces
- Adjustment of hearing aid after a negative trial period
- Home visit audiologist
- Repairs of hearing aids
- Bone anchored hearing aids

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