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# The Association of Health Literacy with Physical Activity and Nutritional Behavior in Older Adults, and Its Social Cognitive Mediators

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*Inadequate health literacy is a common problem among older adults and is associated with poor health outcomes. Insight into the association between health literacy and health behaviors may support interventions to mitigate the effects of inadequate health literacy. The authors assessed the association of health literacy with physical activity and nutritional behavior in community-dwelling older adults. The authors also assessed whether the associations between health literacy and health behaviors are mediated by social cognitive factors. Data from a study among community-dwelling older adults (55 years and older) in a relatively deprived area in The Netherlands were used (baseline* n = *643, response: 43%). The authors obtained data on health literacy, physical activity, fruit and vegetable consumption, and potential social cognitive mediators (attitude, self-efficacy, and risk perception). After adjustment for confounders, inadequate health literacy was marginally significantly associated with poor compliance with guidelines for physical activity (OR = 1.52,* p = *.053) but not with poor compliance with guidelines for fruit and vegetable consumption (OR = 1.20,* p = *.46). Self-efficacy explained 32% of the association between health literacy and compliance with physical activity guidelines. Further research may focus on self-efficacy as a target for interventions to mitigate the negative effects of inadequate health literacy.*

In recent years, health literacy has been shown to be a major determinant of health outcomes and receives increasing attention in science and practice (Green et al., 2013; Ingram & Ivanov, 2013; Muir, Christensen, & Bosworth, 2013; Seurer & Vogt, 2013). *Health literacy* is defined as the degree to which people are able to access, understand, appraise, and communicate information to engage with the demands of

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different health contexts to promote and maintain health across the life course (Kwan et al., 2006). Large-scale health literacy surveys have estimated the rates of limited health literacy to be around 36% (Cutilli & Bennett, 2009) and around 47% (HLS-EU Consortium, 2012) in Western developed countries. Rates of inadequate health literacy have been shown to be higher in adults with older age (Ashida et al., 2011; Kutner, Greenburg, Jin, & Paulsen, 2006; Scott, Gazmararian, Williams, & Baker, 2002; von Wagner, Knight, Steptoe, & Wardle, 2007), low income (Gazmararian et al., 1999; Kutner et al., 2006; Lee, Tsai, Tsai, & Kuo, 2010; Paasche-Orlow, Parker, Gazmararian, Nielsen-Bohlman, & Rudd, 2005), and low educational level (Chinn & McCarthy, 2013; Kutner et al., 2006; Sahm, Wolf, Curtis, & McCarthy, 2012; Scott et al., 2002).

Inadequate health literacy has been shown to be associated with several adverse health outcomes, such as mortality, hospitalization, and emergency care visits (Berkman, Sheridan, Donahue, Halpern, & Crotty, 2011), but little research has focused on the association between health literacy and health behaviors in the general population. However, health behaviors such as physical activity (Brovold, Skelton, & Bergland, 2013; Dhaliwal, Welborn, & Howat, 2013) and fruit and vegetable consumption (Lo, Chang, Wahlqvist, Huang, & Lee, 2012; Södergren, McNaughton, Salmon, Ball, & Crawford, 2012), strongly predict health outcomes. Some cross-sectional surveys suggest that inadequate health literacy is associated with health risk behaviors such as smoking, alcohol use, insufficient physical activity, and insufficient fruit and vegetable intake (Adams et al., 2013; Wolf, Gazmararian, & Baker, 2007), but another survey reported only weak associations between adequate health literacy and healthy eating practices (Speirs, Messina, Munger, & Grutzmacher, 2012). Evidence on the association between health literacy and health behaviors is even more limited regarding older adults, despite them being the population with the highest rates of inadequate health literacy (Ashida et al., 2011; von Wagner et al., 2007), and there is even a complete lack of longitudinal evidence for these associations.

For the development of effective interventions to mitigate the negative impact of inadequate health literacy in older adults, more insight is needed in the associations between health literacy and health behaviors in this group. Insight into the mediators of this association would also be of great value because these might be targets for interventions. Potential mediators of the association between health literacy and health behaviors include attitude towards health behaviors, self-efficacy to perform health behaviors, and perception of the risk of not performing sufficient health behaviors (Adams et al., 2013; Morris et al., 2013; Squiers, Peinado, Berkman, Boudewyns, & McCormack, 2012), but evidence on the role of these social cognitive factors is scarce. Regarding attitudes, only one cross-sectional study is available, which suggests an association between inadequate health literacy and negative attitudes toward health and health care (Morris et al., 2013). Regarding the role of self-efficacy in the pathway from health literacy to various health behaviors, findings are inconsistent. Evidence is available on some behaviors, such as participation in colorectal cancer screening (von Wagner, Semmler, Good, & Wardle, 2009), physical activity (Dominick, Dunsiger, Pekmezi, & Marcus, 2013; Osborn, Paasche-Orlow, Bailey, & Wolf, 2011), and adherence to HIV medication (Colbert, Sereika, & Erlen, 2013; Wolf et al., 2007). However, most studies do not focus on older adults, making it hard to generalize to this population. Last, risk perception has been shown to be associated with positive health behaviors (Brewer et al., 2007; Stephan, Boiche, Trouilloud, Deroche, & Sarrazin, 2011) and might be a potential mediator between health literacy and health behaviors. However, only a single study has indicated an association between adequate health literacy and high risk perception of unhealthy behaviors (Adams et al., 2013).

To get a better insight into the association between health literacy and health behaviors in older adults, we will first assess the associations of health literacy with

physical activity and fruit and vegetable consumption in the population of older adults. After having explored the associations of health literacy with these health behaviors, we will assess whether attitude, self-efficacy, and risk perception mediate these associations.

## Method

### *Design and Setting*

In this study, we used data from the baseline and follow-up measurements of a previously conducted intervention study. This intervention study had a controlled pre-post quasi-experimental design. Data collection consisted of a baseline measurement in December 2011–January 2012 and a follow-up measurement at 9 months after baseline. The intervention community was the small city of Veendam (population around 20,000). The comparison community consisted of a few small villages in the rural area of the municipality of Stadskanaal. Both communities are located in Eastern Groningen—the relatively deprived northeastern part of The Netherlands characterized by a relatively large share of older adults and people with low socioeconomic status. The integrated community-based Groningen Lifestyle Intervention for Seniors adopted a number of strategies (e.g., posters, radio interviews, promotion by peers and professionals, and a lifestyle market) to influence several individual and environmental determinants with the aim of stimulating physical activity and healthy eating among local older adults. The intervention was not specifically developed to improve health literacy. For example, components of the intervention did not focus on health-related information or promoting health-related knowledge. The intervention was delivered during a 3-month high-intensive period, followed by a low-intensive period of 6 months. A more complete description of the intervention has been submitted for publication (Luten, Dijkstra, de Winter, & Reijneveld, 2014).

### *Study Population*

The target group of the intervention consisted of older adults (55 years of age and older), obtained via random sampling from the municipal population registers of both municipalities. A total of 1,000 community-dwelling inhabitants of Veendam and 500 community-dwelling inhabitants of Stadskanaal were invited for the study by a postal letter in which the study purpose, content, and procedures were explained. People could participate in the study by filling in the included questionnaire. As part of the baseline questionnaire, participants gave their consent for participation in the study. After 2 weeks, a reminder followed by post and by telephone to nonresponders. Nine months after baseline, participants received a postal questionnaire for follow-up measurement. A total of 643 participants enrolled in the study at baseline (response: 43%). Of these participants, 564 (88%) participated in the follow-up. Data on health literacy were missing for 26 participants (4.6%), leaving a sample of 538 participants.

### *Data Collection*

Both baseline and follow-up measurements consisted of postal self-report questionnaires, in Dutch. Questions of the different measurements concerned sociodemographic factors (gender, age, education, and income), health literacy, social cognitive factors (attitude, self-efficacy, and risk perception), and health behaviors (levels of physical activity and fruit and vegetable consumption). Data on sociodemographic factors and social cognitive factors were taken from the baseline measurement, while data on the behavioral outcomes were taken from the follow-up measurement.

Because no data on health literacy and monthly income were collected at the baseline measurement, data on these variables were also taken from the follow-up measurement.

Health literacy was assessed by three validated questions (Chew, Bradley, & Boyko, 2004; Chew et al., 2008).

1. ''How often do you have someone help you read hospital materials?''
2. ''How confident are you filling out medical forms by yourself?''
3. ''How often do you have problems learning about your medical condition because of difficulty understanding written information?''

These questions were answered on a 5-point Likert scale (1–5). After reversing the scores on the second question, a total score (3–15) was calculated by summing up the scores of the three questions, with a higher score indicating a higher level of health literacy. Participants who had a score of 12 or lower were classified as having inadequate health literacy, other participants were classified as having adequate health literacy. On the basis of this cutoff point, 35.9% of the participants were classified as having inadequate health literacy. This cutoff point was chosen on the basis of a large-scale health literacy survey in the United States, in which a similar percentage of basic and below basic health literacy was found (Cutilli & Bennett, 2009).

To assess attitude, the participants were asked how important it was for them to engage in sufficient physical activity. Possible responses were ''extremely important,'' ''very important,'' ''important,'' ''fairly important,'' and ''not important.'' A similar question was asked to assess the participants' attitudes toward fruit and vegetable consumption, for which the response categories were ''very important,'' ''important,'' ''fairly important,'' ''unimportant,'' and ''very unimportant.'' For both questions, participants were considered to have a positive attitude if they reported that having sufficient physical activity or fruit and vegetable consumption was at least ''important'' for them.

Self-efficacy for physical activity was assessed by asking participants to what degree they agreed with the following statement, ''I'm sure that, if I wanted to, I would succeed in engaging in more physical activity.'' A similar question was posed to assess self-efficacy for fruit and vegetable consumption. Possible responses were ''strongly agree,'' ''agree,'' ''somewhat agree,'' ''disagree,'' and ''strongly disagree.'' Participants were considered to have high self-efficacy if they reported to ''agree'' or ''strongly agree.''

To assess risk perception of insufficient physical activity, participants were asked to what degree they agreed with the statement, ''If I will not engage in more physical activity, I have an increased risk of getting ill.'' Regarding risk perception of insufficient fruit and vegetable consumption, a similar question was asked. There were five possible responses, ''yes, strongly increased,'' ''yes, increased,'' ''yes, somewhat increased,'' ''no, not increased,'' and ''I don't know.'' The first two responses were considered to reflect a high risk perception. Participants who reported that their risk of getting ill would increase only somewhat or not at all were considered to have a low risk perception, as well as those who reported ''I don't know.''

Levels of physical activity were assessed with the SQUASH, a validated Dutch questionnaire to measure physical activity in adult populations, asking for time spent per day on various physical activities (de Hollander, Zwart, de Vries, & Wendel-Vos, 2012; Wendel-Vos, Schuit, Saris, & Kromhout, 2003). Data from the SQUASH were used to estimate compliance with guidelines for physical activity, that is, at least 30 minutes of moderate intense physical activity ($\geq$4 MET) on at least 5 days a week (Wendel-Vos et al., 2003).

A short questionnaire was used to assess fruit and vegetable consumption. For fruit consumption, participants were asked on how many days a week they consumed

fruit or fruit juice and how much fruit or fruit juice they took. For vegetable consumption, respondents were asked on how many days a week they ate cooked vegetables, raw vegetables, or salads, and how many serving or spoons they consumed. On the basis of these data, a dichotomous measure of fruit and vegetable consumption was calculated regarding compliance with the guidelines for fruit and vegetable consumption, that is, at least 200 grams of vegetables and two pieces of fruit per day.

### *Statistical Analyses*

First, we used chi-square tests to analyze background characteristics, social cognitive factors, and health behaviors of the sample by level of health literacy. Second, we explored the association between health literacy and health behaviors, crude and adjusted for age, gender, and condition (intervention-control) by using logistic regression. Third, we assessed the potential mediating role of attitude, self-efficacy, and risk perception in the associations between health literacy and health behaviors by using the commonly used approach of Baron and Kenny (1986), adjusted for logistic regression analyses. According to this approach, the following conditions must be met in order to establish mediation (illustrated in Figure 1): The predictor variable (health literacy) must significantly predict the potential mediator (association a), the potential mediator (attitude, self-efficacy, risk perception) must significantly predict the outcome (health behavior) when adjusted for the predictor (association b), and the association between the predictor and the outcome (association c) must be substantially lower after adjustment for the mediator (association c'). Association c does not always need to be significant in order to establish mediation effects (MacKinnon, Fairchild, & Fritz, 2007). To assess the strength of the mediation effects, we calculated the decrease in strength of the association between health literacy and the health behaviors due to adjustment for the potential mediator with the formula $(\text{OR[association c]} - \text{OR[association c']})/(\text{OR[association c]} - 1) \times 100\%$. The resulting percentage reflects the proportion of the association between health literacy and the health behavior that is explained by the mediator. In addition, to test the strength of the indirect pathways from health literacy to the health outcomes via the mediators, we fitted a structural model (path analysis) for categorical data, based on polychoric correlations. Compared with the previous method, this path analysis provides a reliable estimation of mediation effects and significance of the total indirect effect, but it does not provide estimates of the magnitude of the effects in odds ratios. Levels of significance and 95% confidence intervals were calculated based on 5000 bootstrap simulations. Finally, we included all potential mediators that reduced the association between health literacy and the health behavior in a model to examine

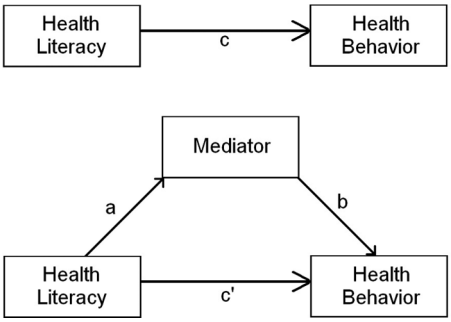


**Figure 1.** Conceptual model of mediation between health literacy and health behaviors.

to what degree they could jointly explain the association of health literacy with physical activity and fruit and vegetable consumption.

Given that our cutoff point for inadequate health literacy might have influenced our results, all our analyses were repeated with an alternative cutoff point. For the alternative cutoff point, participants who had a score of 10 or lower (on a continuous scale from 3 to 15) were classified as having inadequate health literacy, which classified 11.3% of the participants as having inadequate health literacy (compared with 35.9% in our main analyses). We also repeated our analyses without adjusting for age, as age is often considered to have a causal effect on health literacy (Boyle et al., 2013). Our adjustments for age may thus have led to overadjustment in our analyses. To get a better picture of whether the intervention may have influenced our pattern of results, we repeated our analyses with merely baseline data, with the exception of health literacy, as data on health literacy were only available from the follow-up measurement.

For every analysis, only participants for whom all the necessary data were available were included (525 for physical activity, 487 for fruit and vegetable consumption). Because of missing data, the number of participants in different analyses slightly differed. The path analyses were performed using Mplus 7.1 for Windows (Muthén & Muthén, 1998–2012). All other analyses were performed using SPSS 20.0 for Windows.

## Results

Table 1 presents the distribution of the characteristics, social cognitive factors, and health behaviors of the participating older adults by level of health literacy. Compared with the individuals with adequate health literacy, the individuals with inadequate health literacy were older, were more likely to be female, had a lower monthly income, and were more likely to have a low educational level. Among people with inadequate health literacy, there were significantly higher rates of low self-efficacy for both health behaviors. Older adults with inadequate health literacy more often showed poor compliance with the guidelines for physical activity, compared with older adults with adequate health literacy (32.4% vs. 21.7%, $p = .007$). There was no significant difference between people with inadequate and adequate health literacy regarding poor compliance with the guidelines for fruit and vegetable consumption (81.7% vs. 78.8%, $p = .45$).

Table 2 presents the logistic regression models on the association of health literacy with compliance with physical activity guidelines and fruit and vegetable consumption guidelines. After adjustment for condition (intervention-control), age, and gender, there was a marginally significant association between health literacy and compliance with physical activity guidelines (OR = 1.52, CI: 1.00 to 2.31, $p = .053$). The difference regarding poor compliance with the guidelines for fruit and vegetable consumption between older adults with inadequate health literacy and those with adequate health literacy was very small (OR = 1.20, CI: 0.74 to 1.95, $p = .46$).

Further exploration of the data revealed an interaction effect between condition (intervention-control) and health literacy for compliance with fruit and vegetable consumption guidelines (OR = 5.03, CI: 1.75 to 14.45, $p = .003$, not tabulated). A closer look at the data revealed that inadequate health literacy was related to poor compliance with fruit and vegetable consumption guidelines in the intervention group, but to better compliance with fruit and vegetable consumption guidelines in the control group. To examine whether the interaction effect could be the result of the effects of the intervention, we analyzed the interaction between health literacy and condition on fruit and vegetable consumption before the intervention. This analysis yielded a somewhat weaker, but similar effect (OR = 2.91, CI: 0.82 to

**Table 1.** Sociodemographic characteristics, social cognitive mediators, and outcomes of participants by level of health literacy, in percentages

| | Health literacy | | | |
|---|---|---|---|---|
| | Inadequate (35.9%) | Adequate (64.1%) | Total | *p* |
| No. of participants | 193 | 345 | 538 | |
| Sociodemographic characteristics | | | | |
| Age older than 65 years | 64.6 | 48.7 | 54.4 | .001[c] |
| Female | 65.3 | 55.4 | 58.9 | .025 |
| Low educational status | 69.3 | 33.1 | 46.0 | <.001[c] |
| Monthly income under 1350 €[a,b] | 44.6 | 22.0 | 29.8 | <.001[d] |
| Social cognitive factors regarding physical activity | | | | |
| Neutral/negative attitude towards physical activity | 14.3 | 8.8 | 10.7 | .053 |
| Low self-efficacy for physical activity | 56.8 | 32.9 | 41.4 | <.001 |
| Low risk perception of insufficient physical activity | 71.3 | 67.5 | 68.8 | .36[e] |
| Social cognitive factors regarding fruit and vegetable consumption | | | | |
| Neutral/negative attitude towards fruit and vegetable consumption | 13.2 | 11.5 | 12.1 | .58 |
| Low self-efficacy fruit and vegetable consumption | 38.9 | 23.9 | 29.1 | <.001 |
| Low risk perception of insufficient fruit and vegetable consumption | 84.4 | 83.3 | 83.7 | .74[e] |
| Health behaviors | | | | |
| Poor compliance with physical activity guidelines[a] | 32.4 | 21.7 | 25.5 | .007 |
| Poor compliance with fruit and vegetable consumption guidelines[a] | 81.7 | 78.8 | 79.9 | .45 |

*Note.* All *p* values are based on chi-square tests. Rates of missing data on the social cognitive factors regarding physical activity and fruit and vegetable consumption ranged from 1.7% and 6.1%. Data on poor compliance with physical activity and fruit and vegetable consumption guidelines were missing for 2.4% and 9.5% of the participants, respectively.

[a]Measured after the intervention.

[b]A total of 13.9% of participants refused to report their monthly income and were excluded from this analysis.

[c]*p* value is based on three levels.

[d]*p* value is based on five levels.

[e]Separate analyses for subgroups based on compliance with guidelines for the corresponding health behavior revealed that there was no significant association for either subgroup (all *p* values >.6).

10.39, $p = .10$, not tabulated). No relevant interaction effect between health literacy and condition (intervention-control) was found for compliance with physical activity guidelines (OR = 1.09, CI: 0.47 to 2.55, $p = .84$, not tabulated).

As the presence of the interaction effect would impede the interpretability of the results of the mediation analyses for compliance with fruit and vegetable consumption guidelines, we decided to conduct separate mediation analyses for both groups. As these analyses could not be corrected for intervention effects, outcome data from the baseline measurement were used. None of the mediators was significantly associated with compliance with fruit and vegetable consumption guidelines in either group (all $ps > .10$, not tabulated) and none of the indirect pathways reached statistical significance (all $ps > .22$, not tabulated).

**Table 2.** Associations between inadequate health literacy and poor compliance with guidelines for health behaviors, crude and adjusted for potential confounders

| | Poor compliance with physical activity guidelines ($n = 525$) | | Poor compliance with fruit and vegetable consumption guidelines ($n = 487$) | |
|---|---|---|---|---|
| Model | OR (95% CI) | $p$ | OR (95% CI) | $p$ |
| Crude model | | | | |
| Health literacy: Inadequate vs. adequate (ref) | 1.74 (1.16 to 2.59) | .007 | 1.20 (0.75 to 1.92) | .45 |
| Model with condition | | | | |
| Health literacy: Inadequate vs. adequate (ref) | 1.62 (1.08 to 2.44) | .020 | 1.22 (0.75 to 1.96) | .42 |
| Condition: Intervention vs. control (ref) | 0.66 (0.44 to 1.00) | .049 | 1.09 (0.67 to 1.75) | .73 |
| Model with condition, age, and gender | | | | |
| Health literacy: Inadequate vs. adequate (ref) | 1.52 (1.00 to 2.31) | .053 | 1.20 (0.74 to 1.95) | .46 |
| Condition: Intervention vs. control (ref) | 0.65 (0.42 to 0.99) | .045 | 1.06 (0.65 to 1.72) | .82 |
| Age (years) | | | | |
| 55–64 | 1.00 (reference) | — | 1.00 (reference) | — |
| 65–75 | 0.71 (0.45 to 1.12) | .14 | 0.91 (0.56 to 1.49) | .72 |
| >75 | 2.04 (1.17 to 3.56) | .012 | 0.97 (0.49 to 1.91) | .92 |
| Gender: Female vs. male (ref) | 1.40 (0.92 to 2.13) | .11 | 1.17 (0.75 to 1.83) | .50 |

Table 3 shows the results of the mediation analyses for compliance to physical activity guidelines. Neither attitude nor risk perception fulfilled the criteria for mediation, as both the pathways from inadequate health literacy to negative attitude and to low risk perception (association a) and the pathway from negative attitude and low risk perception to poor compliance with physical activity guidelines (association b) failed to reach significance. Adjusting for attitude decreased the association between inadequate health literacy and poor compliance with physical activity guidelines by only a small 8.2%. Adjusting for low risk perception did not decrease the association. Only self-efficacy fulfilled all the requirements for mediation. Inadequate health literacy strongly predicted low self-efficacy to engage in physical activity (OR = 2.36 CI: 1.60 to 3.49, $p < .001$), which in turn predicted compliance with physical activity guidelines when being adjusted for health literacy (OR = 1.76, CI: 1.15 to 2.69, $p < .01$). The association between health literacy and compliance with physical activity guidelines decreased by a substantial 32.0% after adjusting for the effect of self-efficacy, indicating that self-efficacy partially mediates this association. None of the social cognitive factors interacted with health literacy (all $p$s $> .64$, not tabulated), nor with condition (intervention-control; all $p$s $> .43$, not tabulated).

The additional path analyses revealed a similar pattern of results as our main mediation analyses. There was a statistically significant indirect path from health literacy to compliance with physical activity guidelines via self-efficacy (indirect effect = .11, CI: .03 to .22, $p = .03$). The indirect paths from health literacy with compliance with physical activity guidelines via attitude (indirect effect = .04, CI: −.01 to .16, $p = .32$) and risk perception (indirect effect = .01, CI: −.02 to .06, $p = .78$) were not statistically significant.

**Table 3.** Mediation analyses of the association between inadequate health literacy and poor compliance with guidelines for physical activity

| Mediator | *n* | Association a: Health Literacy → Mediator OR (95% CI) | Association b: Mediator → Physical Activity OR (95% CI) | Association c: Health Literacy → Physical Activity OR (95% CI) | Association c': Health Literacy → Physical Activity[a] OR (95% CI) | Decrease effect size[b] |
|---|---|---|---|---|---|---|
| Neutral/negative attitude | 510 | 1.66$^{\#}$ (0.92 to 3.02) | 1.69$^{\#}$ (0.91 to 3.14) | 1.54$^{*}$ (1.00 to 2.36) | 1.49$^{\#}$ (0.97 to 2.30) | 8.2% |
| Low self-efficacy | 507 | 2.36$^{**}$ (1.60 to 3.49) | 1.76$^{**}$ (1.15 to 2.69) | 1.51$^{\#}$ (0.98 to 2.32) | 1.35 (0.87 to 2.09) | 32.0% |
| Low risk perception | 513 | 1.08 (0.72 to 1.64) | 1.44 (0.90 to 2.30) | 1.53$^{*}$ (1.00 to 2.35) | 1.54$^{*}$ (1.00 to 2.35) | –0.3% |

*Note.* All analyses were adjusted for effects of condition (intervention/control), age, and gender. Associations a to c' refer to the associations that are illustrated in Figure 1.

[a]Adjusted for the mediator.

[b]Difference in effect size between association c and association c' calculated as follows: $(OR[c]-OR[c'])/(OR[c]-1)\times 100\%$.

$^{\#}p<.10$. $^{*}p<.05$. $^{**}p<.01$.

**Table 4.** Association of inadequate health literacy with poor compliance with guidelines for physical activity, with sequential adjustment for potential confounders and mediators ($n = 496$)

| Adjusted variable | OR (95% CI) | $p$ |
|---|---|---|
| None | 1.77 (1.17 to 2.69) | .007 |
| Condition | 1.67 (1.10 to 2.55) | .017 |
| +Age and gender | 1.56 (1.01 to 2.41) | .044 |
| +Self-efficacy | 1.40 (0.90 to 2.18) | .14 |
| +Attitude | 1.39 (0.89 to 2.17) | .15 |

Table 4 shows the association between inadequate health literacy and noncompliance with guidelines for physical activity with sequential adjustment for confounders and potential mediators. Because of missing data on the confounders and potential mediators, the numbers in this table slightly differ from the numbers in previous tables. The addition of self-efficacy to the model caused a substantial drop in the association between inadequate health literacy and noncompliance with physical activity guidelines. Adding attitude to the model already containing self-efficacy proved to cause only a very minor further change in the association between inadequate health literacy and non-compliance with physical activity guidelines. Adding risk perception to the model did not cause any further change (results not shown).

To assess the influence of some choices during the analyses, we repeated our analyses three times: Once with the alternative cutoff point for health literacy, once without adjusting for age, and once with merely health behavior data from the baseline measurement. All three sets of analyses yielded findings that were very similar to our primary analyses. In every set of analyses, self-efficacy was the only social cognitive factor that fulfilled all criteria for mediation between health literacy and compliance with physical activity guidelines and had a statistically significant indirect effect on compliance with physical activity guidelines via health literacy ($p < .05$ in every analysis).

## Discussion

### *Main Findings*

To our knowledge, this was the first longitudinal study to investigate the association between health literacy and health behaviors and its potential mediators among older adults. After adjustment for condition (intervention-control), age, and gender, we found a negative, marginally significant association between inadequate health literacy and physical activity. No meaningful association between inadequate health literacy and fruit and vegetable consumption was found. Of the examined potential social cognitive mediators, only self-efficacy could explain a substantial part of the association between health literacy and physical activity. No relevant mediation effects of attitude or risk perception were found.

Our study is among the first to investigate the association between health literacy and health behaviors among older adults. The finding that inadequate health literacy is associated with poor compliance with physical activity guidelines is in line with the results of a cross-sectional survey, which showed that older adults with inadequate health literacy are more likely to have a sedentary lifestyle compared with their counterparts with adequate health literacy (Wolf, Gazmararian, et al., 2007). These results indicate that improving health literacy might be a productive way to increase the

physical activity of older adults. However, high quality intervention studies are needed to establish causal conclusions. Our finding that the association between health literacy and physical activity is stronger than the association between health literacy and fruit and vegetable consumption is in line with the findings of a recent cross sectional study (Adams et al., 2013) and with a survey study that suggested that adequate health literacy is only weakly associated with healthy eating practices in a low income population (Speirs et al., 2012). This pattern of results suggests that the impact of health literacy varies across different health behaviors.

Our results regarding the association between health literacy and fruit and vegetable consumption have to be interpreted with caution, because of an unexpected interaction effect between health literacy and condition (intervention-control). As a similar interaction effect was already present before the start of the intervention, it is unlikely that this effect resulted from the intervention. An explanation may be a difference in urbanity between the two groups. The intervention group came from the center of Veendam (a small city with around 20,000 inhabitants), but the control group came from several smaller villages in a more rural area. Dean and Sharkey (2011) have shown that fruit and vegetable consumption depends on different factors in rural and urban environments. In their study, they suggest that food security and distance to food sources play a larger role in rural settings, as compared with urban settings (Dean & Sharkey, 2011). Also, possibly more people in rural areas cultivate their own fruits and vegetables. The association between health literacy and fruit and vegetable consumption may thus be dependent on the level of urbanization in a specific area. More research on the role of environmental characteristics in the associations between health literacy and health behaviors could be relevant to better tailor initiatives to improve health outcomes in older adults with inadequate health literacy.

Self-efficacy proved to be an important mediator in the pathway from health literacy to physical activity, in contrast to attitude and risk perception. Adjusting for self-efficacy strongly decreased the association between health literacy and physical activity. This is in line with some previous studies that suggested a pathway from health literacy to physical activity via self-efficacy and knowledge (Osborn et al., 2011), and that self-efficacy is directly associated with physical activity in older adults (Ayotte, Margrett, & Patrick, 2013). Self-efficacy was also suggested to mediate between health literacy and health behaviors in patients in a number of other studies (Bohanny et al., 2013; Osborn, Cavanaugh, Wallston, & Rothman, 2010; Wolf et al., 2007), but not all studies support this association (Chen et al., 2014; Colbert et al., 2013). It is possible that the associations between health literacy and self-efficacy vary between different types of health behaviors, between different groups of people, or between different measurement tools for both constructs.

Our results thus suggest a mediating role of self-efficacy, but mechanisms may be more complex too. For example, we speculate that older adults with adequate health literacy are more motivated to improve their physical activity. Successfully engaging in more physical activity may then improve their self-efficacy (McAuley et al., 2008), which may, in turn, help them to keep engaging in sufficient physical activity (Janssen, Dugan, Karavolos, Lynch, & Powell, 2014). However, even if the actual associations are more complex than our model suggests, our results indicate that interventions that aim to improve self-efficacy for physical activity in older adults could potentially be productive to mitigate the negative effects of inadequate health literacy among older adults.

In our study, we examined whether attitude, self-efficacy, and risk-perception are mediators in the pathway from health literacy to health behavior. However, other mediators that were not evaluated in this study may also play a role in this association. An example of this may be outcome expectancies (Heinrich, Maddock, & Bauman, 2011). This deserves further study.

### *Strengths and Limitations*

A strength of our study was that we used data from community-dwelling older adults from a relatively deprived area in the Northern part of The Netherlands.

However, we should also consider some limitations of this study. First, we used data from an intervention study with a moderate response rate. Second, although we assessed associations and potential mediation, our findings regarding associations do not automatically infer causal relationships. Third, data on health literacy were only available from the follow-up measurement. There is no general consensus about the stability of health literacy (Berkman, Davis, & McCormack, 2010), but one longitudinal study suggests that health literacy gradually decreases over time in older adults above the age of 65 years (Morris, MacLean, & Littenberg, 2013). However, as the follow-up measurements in our study were taken after only nine months and the intervention was not specifically developed to improve health literacy, it is unlikely that health literacy underwent major changes between baseline and follow-up. Fourth, the tools used to measure the social cognitive factors in this study consisted of only a single question. This may have added measurement error, potentially leading to an underestimation of actual mediation effects. Also, participants who complied with the guidelines for sufficient health behavior may have interpreted the questions on risk perception differently than those who did not comply with these guidelines. However, no associations between health literacy and risk perception were found in separate analyses for these groups. This indicates that it is unlikely that the results of our mediation analyses were influenced by varying interpretations of the questions on risk perception.

### *Implications*

Our results suggest that self-efficacy mediates the association between health literacy and compliance with physical activity guidelines in older adults. This indicates that interventions to improve the self-efficacy of older adults may be productive to mitigate the negative effects of inadequate health literacy. However, high quality intervention research is required to improve our understanding of causal relations. To our knowledge, our study was the first longitudinal study among older adults to explore potential mediators in the pathway from health literacy to health behaviors. Therefore, replication of this study is needed. Future research could also comprise a wider range of health behaviors and include more potential mediators. More insight in the association between health literacy and health behaviors and the mediators and moderators of this association could be valuable for future interventions that aim to limit the problems that are associated with low levels of health literacy in older adults.

### *Conclusions*

Inadequate health literacy is associated with poor compliance with guidelines for physical activity, but not with poor compliance with guidelines for fruit and vegetable consumption. Self-efficacy partially mediates the association between inadequate health literacy and poor compliance with guidelines for sufficient physical activity.

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