Physical activity in a multi-ethnic population: measurement and associations with cardiovascular health and contextual factors

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Chapter 8

General discussion
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In this chapter we will discuss the main findings of our studies. This general discussion consists of five parts. Part 1 contains a brief summary of the main findings. Part 2 raises some general methodological considerations concerning the data and analyses that were used. Part 3 offers a general reflection on some of the main findings. In light of these findings, Part 4 contains a reflection on some general recommendations for ethnicity and health research. Finally, Part 5 of this chapter will contain the main conclusions of this thesis.

Part 1 - Summary of the main findings

This summary of the main findings describes the results from our studies, and is structured by the original research questions described in the general introduction of this thesis (Chapter 1). In short, the first objective was to describe ethnic differences in domains and types of physical activity, and to assess ethnic differences in the relationship between these domains and types of physical activity and the recommended level of physical activity in the South Asian-Surinamese and African-Surinamese compared to the European-Dutch (research question 1). The second objective was to assess the ethnic differences in the relationship between physical activity and cardiovascular disease (CVD) and CVD-related risk factors in the South Asian-Surinamese and African-Surinamese compared to the European-Dutch (research question 2a, 2b, 2c). The third objective was to assess the relationship between environmental and socioeconomic factors and physical activity in the Surinamese ethnic groups compared to the European-Dutch (research question 3a-b). A summary of the main findings for each of the questions posed in the introduction is given below.

1. How are physical activity domains and culturally specific types of physical activity related to differences in recommended levels of physical activity in the South Asian-Surinamese and African-Surinamese compared to the European-Dutch?

We observed marked differences in types of physical activity between the ethnic groups included in the SUNSET (Surinamese in the Netherlands: Study on Health and Ethnicity) study population for the various domains of activity (Chapter 2). In addition, ethnic differences were observed regarding frequency, intensity, and duration (volume measures) within the domains. Ethnic differences in attaining recommended levels of physical activity were related to the included domain of activity.

South Asian-Surinamese women had lower levels of recommended physical activity in all domains compared to European-Dutch women. Lower levels of recommended physical activity were also observed among the South Asian-Surinamese men and the African-
Surinamese groups, although these were not statistically significant. The magnitude of the contribution of ethnic differences in recommended physical activity varied between the considered domains of physical activity. For example, commuting physical activity was found to be popular among the European-Dutch participants, and therefore contributed to the ethnic differences. In contrast, the longer duration of vigorous occupational physical activity in the Surinamese groups did mitigate ethnic differences in recommended physical activity to some extent. Finally, we observed that culturally specific types of physical activities (such as yoga and dancing) also mitigated ethnic differences in recommended physical activity, although this was only slight.

2a. Are there differences in the association between low physical activity and CVD-related hospital discharge in the South Asian-Surinamese or African-Surinamese compared to the European-Dutch?

There were some ethnic differences in the individual ethnic groups in the estimated hazard of a low level of physical activity and CVD-related hospital discharge, although these did not reach statistical significance in an overall test for interaction. After a median of 5 years of follow-up, the hazard ratios for the ethnic groups regarding low physical activity and CVD-related hospital admission were 1.55 (95% CI: 0.73–3.30) in the European-Dutch, 1.53, (0.76–3.05) in the South Asian-Surinamese, and 2.77 (1.31–5.87) in the African-Surinamese (Chapter 3).

2b. Are there differences in the association between low physical activity and type 2 diabetes in the South Asian-Surinamese or African-Surinamese compared to the European-Dutch?

There was no statistically significant ethnic difference (interaction) in the association between low physical activity and type 2 diabetes, although the estimated odds ratio (OR) was significant in the European-Dutch (OR 3.17, 95% CI: 1.37–7.30) compared to the weaker associations in the African-Surinamese (OR 1.13, 95% CI: 0.58–2.19) and South Asian-Surinamese (OR 1.43, 95% CI: 0.78–2.63) individuals (Chapter 4).

2c. Are dimensions of physical activity (intensity, duration) more consistently associated with HDL cholesterol and triglycerides than a total score of physical activity in the South Asian-Surinamese, African-Surinamese, and European-Dutch?

Total physical activity was associated with HDL cholesterol and triglyceride levels only in the African-Surinamese group (Chapter 5). Further investigation into the intensity and duration components of the total score revealed that the intensity component of physical activity was consistently associated with triglyceride levels in all ethnic groups, and with HDL cholesterol levels in the European-Dutch and African-Surinamese groups. The duration of physical activity was not associated with any outcome measure except HDL cholesterol level in the African-Surinamese group. These results suggest that as a measure,
total physical activity is not as good for assessing the relationship between physical activity and HDL cholesterol and triglycerides in this multiethnic population as the more consistent association between intensity of physical activity and HDL cholesterol and triglycerides across ethnic groups.

3a. Are there differences in the association between socioeconomic position and active commuting and leisure-time physical activity in the South Asian-Surinamese and African-Surinamese compared to the European-Dutch?

We found a differential association between active commuting and socioeconomic position across ethnic groups (Chapter 6). The positive association we found between active commuting and level of education was strongest in European-Dutch men compared to the South Asian-Surinamese men and there was lack of association in African-Surinamese men; although the pattern appeared similar, this was not the case for occupation (non-manual compared to manual). Among women, a similar pattern of ethnic differences was observed across the ethnic groups, but for occupation only. For leisure-time physical activity, we were unable to observe a clear pattern of differences in the association with socioeconomic position between the ethnic groups in either men or women.

3b. Do differences in leisure-time physical activity between the European-Dutch population living in the Netherlands and the European-English population living in England reflect similar differences in the South Asian- and African-descent populations living in these two countries?

We observed that the Dutch ethnic groups (both the European-Dutch and the ethnic minority groups) reported cycling and sports participation more frequently than their English counterparts (Chapter 7). The English groups (both European-English and English ethnic minorities) reported gardening as an activity more frequently than the Dutch groups. This finding provides indications suggesting that differences between countries in some of the major types of leisure-time physical activities reflect similar differences in the ethnic minority groups. Additionally, within each country we observed that the prevalence of leisure-time physical activity was lower for gardening and cycling among those of South Asian and African descent and lower for 30-minute walking among English South Asians, but higher for dancing among those of African descent compared to the European-descent populations. Although differences by duration of residence were observed, these were small and not as consistent.

Part 2 - Methodological considerations

Each individual study in this thesis includes a section that discusses the specific limitations related to the analyzed data. Before reflecting on the main findings and coming to the general conclusions of this thesis as a whole, though, some general methodological issues
need to be addressed. This part will address general factors that relate to internal validity, or how well the results of the study relate to the target population, and addresses non-response, measurements, other validity considerations, and analyses, as well as external validity relating to the generalizability of our study results.

**Internal validity**

**Non-response**

Internal validity is being influenced by the non-response of the original selected study population. In the original SUNSET study, the overall response to the interview was 60%. Non-response bias might occur when respondents differ in certain characteristics compared to non-respondents with regard to the outcome under study. For example, non-responders can be in poorer health, which might influence the interpretation of the associations presented in this study. Looking further into differences between responders and non-responders in the SUNSET study, we found that responders were likely to differ in terms of family status (more likely to be married and living with a partner and/or children), age (higher), income (higher), and “urbanicity” (living in a less densely populated neighborhood). However, reported differences were small, and non-response characteristics were similar among the ethnic groups. Although we only measured a limited set of variables, this can be used as an indication that the study sample is likely to be similar to the original sample, and that observed ethnic differences in the limited set of measured characteristics are not related to non-response.

The overall response to the interview in the Health Survey for England (HSE) was higher than what was observed in the SUNSET study: the average household response from 1999 and 2004 combined was 74% in the general population and 70% in the ethnic minority boost sample known to be eligible. From the participating households, the combined 1999 and 2004 individual response in the general population sample was 91%, and this was 88% in the ethnic minority boost sample. The HSE data comes with a correction weight to account for selection and non-response on various levels, depending on the variables included in the analyses. Because this weight was applied in our analyses, non-response in the HSE is unlikely to influence the internal validity of the study.

**Measurements**

The physical activity measurement tool used in our studies was validated in a European-Dutch population. The validation study showed a fairly reliable test-retest correlation and correlation coefficient with an electronic activity monitor, which fell within a similar range compared to other comparable physical activity questionnaires. Therefore, the Short Questionnaire to Assess Health-Enhancing Physical Activity (SQUASH) was considered to be a fairly reliable and reasonably valid questionnaire. Unlike the validation study, the physical activity questionnaire was interviewer-administered by trained interviewers in the
SUNSET study to enhance reliability of the data in the entire study population. Additional activities were added, including an open-ended question to minimize the risk of missing information on specific physical activities in the Surinamese groups.

Possible causes that may lead to measurement error in self-reported physical activity questionnaires might be social desirability bias or cognitive recall bias. One study found that social desirability bias was observed at minimal levels in college students. It is unclear how much social desirability bias would affect our measurement of physical activity across ethnic groups, but since physical activity is not a very sensitive topic to disclose, this bias is expected to be low. Difficulty with the recall of self-reported physical activity levels seems especially relevant when recalling duration of activity and the lower-intensity activities; this difficulty is expected to apply similarly across ethnic minority groups. However, household and occupational physical activity was reported more often in the Surinamese groups, which gives rise to the possibility that, particularly for these groups, household activity and occupational activity were overestimated by the questionnaire. Given the contribution of this domain in mitigating ethnic differences in recommended level of physical activity, the reported ethnic differences in recommended physical activity might be an underestimation of the true differences.

Another form of bias in physical activity research can be seasonal variation, especially when different groups are interviewed in different seasons. The most optimal seasons for measuring physical activity are spring and fall, when the average resembles the year-round average, which will reduce intraindividual variability. The period of data collection was from 2001 to 2003, during which an equal number of participants from each ethnic group was interviewed across the seasons. Although this was not the most optimal in terms of intraindividual variability of physical activity, we believe that seasonal influence is less of an issue in the SUNSET study and that ethnic differences were not greatly affected. Additionally, the questionnaire measures an average week of physical activity.

Cultural differences in reporting physical activity behavior might lead to structural ethnicity-specific measurements, which could make direct physical activity comparisons in absolute level of physical activity between ethnic groups less valid. Therefore, we often use relative comparisons for our physical activity analyses between the ethnic groups. Additionally, language validation was not necessary in our multiethnic study population, because previous research showed that only 5% of the Surinamese population has difficulty with the Dutch language (Dutch is the official national language in Suriname); in our study population this appeared to be less than 2%.

CVD was assessed with a derived Rose questionnaire (including questions on previous diagnoses of angina pectoris/myocardial infarction, cerebrovascular accident, and intermittent claudication), which has proven to be a valid tool for CVD epidemiology. Self-report by the participant might be prone to measurement error, since CVD could not be verified by a clinician or medical records. The results from our linkage study to the
national hospital registry confirm the previously reported higher levels of CVD observed in the Surinamese groups in the baseline measurement. Anthropometry and biomedical measurements were obtained twice in the medical center according to protocol. Blood pressure was measured twice according to a strict protocol. Plasma glucose, HDL cholesterol, and triglycerides were based on a single measurement of a fasting plasma sample obtained during the medical examination. It is generally better to obtain multiple measurements over time, which would give more precise estimates. This error is expected to be similar across ethnic groups and would therefore not limit comparability between ethnic groups.

Most of the studies included in this thesis use data from the original SUNSET study, which was based on a cross-sectional sample of the population. The results from our studies (except for Chapter 3) should therefore be interpreted with caution. These models were based on causal inference rather than true causal effects. However, the results from our follow-up analysis (Chapter 3) were in agreement with causal inference; the hazard of a CVD-related hospital discharge in participants with a low level of physical activity within five years after the baseline interview was almost twofold higher than those with a high level of physical activity.

Other validity considerations

Some other forms of bias that could have influenced the internal validity of the study are instrumentation bias, history threat, loss to follow-up bias, and construct validity, which are discussed below.

Instrumentation bias might arise when measurement tools are changed over time. While the SUNSET study data was gathered from one point in time, the HSE collected physical activity data in 1999 and 2004. The instrument in the HSE was changed slightly for the physical activity measurement, although these changes did not influence the prevalences for the specific types of leisure-time physical activity presented in our study. Additionally, a history threat might occur if unmeasured events that influence the outcome take place before the questionnaire or medical examination. For example, there was a relatively short period of time between the interview and the medical examination in which unmeasured events might have influenced the data from the medical examination. Participants might have received a CVD-related diagnosis from a doctor in between the interview and the medical examination that included the suggested lifestyle modifications. However, these events are expected to be similar across the ethnic groups, and therefore have no influence on the general conclusions.

There might be loss to follow-up bias in the follow-up study (Chapter 3). We were unable to gather some intermediate addresses of the SUNSET respondents, which were important for the linkage with the national hospital registry, especially if people with higher CVD risk had moved away (either within the Netherlands or abroad). The results of a propensity score analysis suggested this was not likely to be the case.
Construct validity refers to the measurement and operationalization of physical activity and how this relates to CVD or CVD risk factors. Certain choices of measurement and operationalization of physical activity may lead to biased ethnic differences in physical activity and CVD or CVD risk factors. In this thesis, we show there can be ethnic differences in the associations between physical activity and the outcome of interest (Chapter 2, Chapter 5), depending on both the measurement and operationalization of physical activity and the outcome of interest.

**Analyses**

Associations are said to be confounded when there is a third variable in the conceptual model that is related to both the outcome and predictor variable of interest. In most of our studies we adjusted for confounding by age and sex, two factors that influence health and physical activity. Other variables of potential importance that were considered in the different studies because of expected confounding were level of education, job status (employed/unemployed), occupational class (manual/non-manual or more elaborate categorizations), current smoking, familial history of type 2 diabetes, history of CVD, metabolic syndrome, and body mass index (BMI).

In the association between physical activity and CVD, BMI is considered to be both a confounder and an intermediary variable. This complicates the analysis. Conceptually, one part of the disease risk can be explained by higher levels of BMI. Higher levels of BMI can be due to lower levels of physical activity, but lower levels of physical activity are also directly related to disease risk. This was impossible to disentangle in this cross-sectional study, due in part to the relatively small number of observations in each group. Since the overall effect of physical activity on cardiovascular health was of primary interest in this thesis, and not which part could be explained by each of these two factors, BMI was left out of most of the models (except for the association between physical activity and type 2 diabetes in Chapter 4).

Additionally, due to the lack of an extensive measurement of diet, we could not properly take the effect of diet into account in our studies, and this might therefore be a source of unmeasured confounding.

**External validity**

Most of the studies included in this thesis were based on a population sample from different neighborhoods in the Dutch city of Amsterdam. Therefore, we have to be cautious about the generalizability of our findings to South Asian-Surinamese and African-Surinamese groups living in other locations, especially in terms of absolute prevalence of certain types of activity. For example, a lower prevalence of sports participation was reported in the Surinamese groups in Amsterdam compared to the Surinamese in Rotterdam. However, relative to the level of physical activity observed in the European-Dutch, both cities show lower rates of sports participation in the Surinamese groups. Therefore, we assume that the
presented relative patterns of physical activity compared to the European-Dutch might be applicable to other Surinamese groups living outside of Amsterdam. Because of the expected differences in socioeconomic position and differences in local context compared to the larger cities, we assume a limited generalizability for Surinamese groups living in the relatively smaller cities. Additionally, because of the expected changes in the composition of socioeconomic position in a population over time, these patterns are expected to change over time. Although we assume that the identified patterns in physical activity cannot be generalized to other ethnic minority groups living in the Netherlands, some of the conclusions regarding the measurement of physical activity might be very applicable to physical activity research in other ethnic minority groups.

Part 3 - Reflections on the main findings

This section reflects on some general main findings from our studies. More specific discussion is available in the individual studies included in the previous chapters. Here we will reflect on three topics: measurement of physical activity, the relationship of physical activity with CVD, and cross-national comparison of physical activity.

Measurement of physical activity

Within health research there is a need to accurately identify complex behaviors such as physical activity, as this can give important insights into disease etiology. Specific patterns of physical activity that are especially important to lowering disease risk might be different across ethnic minority groups. The question is whether we are measuring ethnic differences in physical activity accurately. The results from this thesis show that even slight changes in the definition of physical activity (in terms of which domains and types of activity are covered by the questionnaire) have an effect on the estimated ethnic differences in recommended level of physical activity (Chapter 2). One of the explanations is that the underlying pattern of physical activity within domains (in terms of frequency, duration, and intensity of activity) differs widely between ethnic groups. Therefore, to accurately identify physical activity, especially in a multiethnic setting, extensive questionnaires are needed to cover the range of physical activities people can engage in.

In addition, it is important to look beyond a summary measure of physical activity in terms of below and beyond the recommended level. Previous studies have shown that physical activity has been identified as being linearly related to CVD. The positive effect of physical activity on CVD is also observed below the recommended level. Therefore, it seems that physical activity is best described on a continuous scale rather than with a dichotomous measure. This is also acknowledged in a study among African-Americans (although using a different physical activity questionnaire than in our study): a continuous score of physical activity was more consistently related to an objective measure of physical activity than the
calculated recommended level of activity.\textsuperscript{13} When using a continuous scale compared to a recommended level of activity, it is especially important to accurately measure all types of physical activity to make an accurate ethnic group comparison.

**The relationship of physical activity with CVD**

In Chapter 3-5, different measures of physical activity and ethnic differences in the associations of physical activity with CVD and CVD risk factors were assessed. For example, the relationship between low physical activity (in terms of a <75% cutoff value of a total physical activity score) and CVD-related hospital discharge was similar across ethnic groups over a median period of five years of follow-up (Chapter 3).

The importance of choosing an accurate definition of physical activity with respect to the outcome under study has been suggested before,\textsuperscript{14} and this seems to be the case especially when comparing ethnic groups. In Chapter 5, for example, the intensity score of activity was more consistently related to beneficial levels of blood lipids than the total physical activity score. Another argument for an accurate definition is that low-intensity physical activity, unstructured physical activity, or physical activity with a relatively long duration seems less well captured by self-reported physical activity questionnaires.\textsuperscript{15} The finding that different ethnic groups have differences in composition of physical activity (Chapter 2) (and therefore also in terms of the amount of less well captured activity) might add relatively more measurement error across ethnic groups. Basically, this could result in a less well captured measure of total physical activity. Because activities that are more intense are less influenced by this measurement error, this relates more consistently to blood lipids across ethnic groups. This might be another reason why intensity of activity was more consistently related to blood lipids than the total physical activity score in our study. Therefore, it seems important to first pose the research question and hypothesis, and then try to identify which measure of physical activity might best suit the relationship with the health outcome across ethnic groups. For example, it is probably wise to supplement the total physical activity score with an objective measure of physical activity when this is manageable in terms of the extra associated cost, or otherwise present additional measures of physical activity that are expected to be more suitable in association to the outcome of interest (such as intensity of activity).

The results described in Chapter 3-5 suggest that the mechanism by which physical activity is associated to cardiovascular health is similar across ethnic groups, but that differences in operationalization of the measurement can give rise to ethnic differences in the relationship with health. Other studies that identify differences in the association between physical activity components and health outcomes might therefore have used a different definition of physical activity. An example of this would be selecting a small range of activities that includes sports and exercise to relate to the outcome and, as a result, indirectly focusing more on those activities with higher intensity.\textsuperscript{16,17} Additionally, other explanations for studies that identify a different strength of the association across ethnic groups might have to do with the combination of a nonlinear dose-response curve and
a different distribution (or range) of the exposure within the population under study. This can be illustrated by the position on the dose-response curve for physical activity, which might be different for different ethnic groups (Figure 1). For example, in Chapters 2 and 5, the African-Surinamese have been identified with a slightly lower recommended level of physical activity, a lower intensity component score, but with a higher duration component score compared to the European-Dutch. This different distribution in physical activity components might be why the African-Surinamese showed a stronger association between physical activity total score and CVD-related hospital discharge and blood lipids compared to the other ethnic groups. The South Asian-Surinamese, on the other hand, had a lower level of recommended physical activity and lower levels of intensity and duration component scores compared to the European-Dutch. The South Asian-Surinamese were also characterized in the sample as the smallest group in terms of absolute size in number of participants compared to the African-Surinamese and the European-Dutch. In some of the stratified analyses, this low level of physical activity and a small number of observations in the South Asian-Surinamese group might have been too small (i.e. resulting in large

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**Figure 1.** Hypothetical dose-response relationship between physical activity component and disease

The distribution of physical activity observed within a population might limit the range in observed outcome. In this example, in terms of a lower rate of disease, Population 1 benefits relatively more from a 1-point increase in physical activity than Population 2. Because Population 2 already has high absolute levels of physical activity and a lower rate of disease than Population 1, the relative benefit of a 1-point increase in physical activity is therefore lower than in Population 1. (Adapted from: Lee, 2009.)
confidence intervals) to detect the positive association with disease. Further research is necessary to test this hypothesis.

**Cross-national comparison of physical activity**

Because of the importance of country context on ethnic inequality in health, we hypothesized that patterns of convergence in physical activity behavior could be better tested between countries. The cross-national analysis (Chapter 7) suggests the importance of the national context in the leisure-time physical activity behavior of both the majority population of European descent and the ethnic minority groups living in the Netherlands and England. On the national level, it shows there are large differences between the countries in prevalence of some popular types of leisure-time physical activity. The Dutch populations (including the Dutch ethnic minority groups) were more active in terms of cycling and playing sports than the English groups, while gardening was reported more often in the English population groups (including the English ethnic minority groups).

Within countries, duration of residence as indicator of convergence in prevalence of leisure-time physical activity in the ethnic minority groups compared to the majority population was less influential than the pattern of differences observed between countries. This is in line with the criticism that duration of residence as indicator of convergence has received in the past.20

The results from the cross-national comparison suggest a clear pattern of convergence (at least up to a certain amount of physical activity) for cycling and playing sports in the Dutch neighborhoods in South Asian-Surinamese and African-Surinamese ethnic minority groups compared to the more positive influence of gardening in the English neighborhoods in the South Asian and African-Caribbean ethnic minority groups.

Our current findings of higher levels of leisure-time physical activity in the South Asian-Surinamese and African-Surinamese ethnic minority groups living in the Netherlands as compared to their English counterparts are in contrast with the higher levels of obesity and diabetes reported among the Dutch ethnic minority groups.21,22 Given the beneficial effect of physical activity on health, we would expect these patterns of obesity and diabetes to be the reverse. Explanations for these discrepancies are unclear. It may very well be that the underlying components of physical activity are more beneficial in the English ethnic minority groups than in the Dutch ethnic minority groups. Unfortunately, we were unable to look further into the underlying components of physical activity because of limitations in the overlap of the measurement of physical activity. Furthermore, it may also be possible that other unfavorable lifestyle factors play an additional important role, for example, the higher prevalence of smoking observed in the Dutch ethnic minority groups compared to their English counterparts.23 Although these findings are interesting and more work is clearly needed on this topic, this is beyond the scope of this thesis.
Part 4 – Implications and recommendations

Implications for prevention and policy

In terms of health improvement, both the South Asian-Surinamese men and African-Surinamese men scored 10% lower on the recommended level of physical activity (this measure included all domains and culturally specific activity) compared to the European-Dutch. African-Surinamese women were similar in terms of recommended level of physical activity compared to European-Dutch women. The South Asian-Surinamese ethnic minority population might benefit the most from an increase in physical activity. In absolute terms, South Asian-Surinamese women were least active compared to European-Dutch women in almost all domains and activities, leading to a 20% lower adherence to the recommended level of physical activity compared to European-Dutch women. This, together with the results that a low level of physical activity is related to a higher hazard of CVD-related hospital discharge, puts physical activity stimulation in the South Asian-Surinamese group high on the public health agenda.

People who work with public health recommendations – for example, general practitioners and clinicians, and also policy developers who focus on physical activity – should be aware of the diverse activities people can engage in. For example, South Asian-Surinamese men reported an almost 10% prevalence of yoga and the African-Surinamese group reported an approximately 30% prevalence of dancing in their leisure time, which was a higher level than in the European-Dutch. These activities diminished the ethnic differences in recommended level of physical activity in these groups. Recently, the American College of Sports Medicine released an updated position stand to guide clinical practice regarding exercise prescription: in addition to exercising regularly (according to an individual’s habitual physical activity), there are health benefits to reducing sedentary time in daily life. Between 20% and 40% of the ethnic minority populations reported regular bicycle use in their leisure time, while only 6% to 13% use bicycles to commute, compared to about 30% of the European-Dutch population, which also shows opportunities for increasing physical activity in daily life.

The general idea is that policy developers (not only those in health departments) can stimulate levels of physical activity in the population by incorporating beneficial changes into the structural environment for stimulating physical activity. This general idea is supported by our cross-national analyses: that the prevalence of popular leisure-time physical activity is country-specific and, up to a certain level, is being reflected in the ethnic minority groups compared to the European-descent population.

Another point that can be relevant for policy is that the specific situation in terms of level of physical activity in the local country can differ when compared to neighboring countries. When data are unavailable, a good starting point is to focus on evidence from other countries. However, the physical activity situation (in terms of a list of popular types of physical activities in the local country, including activities that are popular in the ethnic
minority groups) should be set out prior to developing policy to support or stimulate certain types of activities.

Additionally, something that constitutes a high-risk group for developing CVD in European-descent groups (such as low socioeconomic position) and which is being used in prevention programs to stimulate healthy behaviors may not work equally well in the ethnic minority groups. For example, socioeconomic position seems related to commuting activity in the European-Dutch, but this relationship seems weaker or absent in the ethnic minority groups.

**Recommendations for future research**

In several chapters in this thesis the observed physical activity patterns were different between ethnic groups with regard to either type of activity or individual components (intensity, duration, frequency) of physical activity. By presenting summary scores of physical activity these characteristics are lost, sometimes resulting in unexpected associations with health. Presenting a summary measure such as adherence to recommended level of physical activity might aid in deciding whether the majority population needs an intervention (for instance, because of very low levels of physical activity) or whether national policy is having an effect. However, presenting such estimates might hide very important underlying ethnic differences in the composition of activity in domains or underlying components, which can relate differently to the adherence to recommended level of physical activity and cardiovascular health in ethnic minority groups compared to the majority population.

One recommendation that would aid in understanding physical activity and health across ethnic groups would be to present both summary measures (such as recommended level of physical activity or total physical activity score) and volume components separately. Extensive physical activity measurement tools are therefore preferred in ethnicity and health research, as there is less chance of missing specific physical activity (including culturally specific physical activity). Extensive measurement tools are also more flexible to choose the physical activity component of interest, or to update according to new criteria/definitions of recommended level of physical activity.

When a total physical activity score is chosen based on questionnaire data, it might be worth supplementing the extensive physical activity questionnaire with some form of objective physical activity measurement (such as the electronic monitor). This can be especially useful in identifying the amount of low-intensity, unstructured, or physical activity of relatively long duration (such as household and occupational activity), which is difficult to assess with questionnaires. Otherwise, additional components of physical activity (such as intensity of activity) could provide further insight into differences in the composition of physical activity between ethnic groups.

Future physical activity studies should explicitly define which domains of activity were assessed, which underlying assumptions were made regarding cutoffs for moderate- and vigorous-intensity activity, and which components were included in the physical activity score and which measure of physical activity was chosen, and for what purpose. Although
this explicit operationalization should, of course, be a general recommendation for future physical activity research, this seems especially important when making ethnic group comparisons.

The SQUASH physical activity questionnaire we used was validated in the European-Dutch population. Additionally, it was found to perform better than another frequently used Dutch physical activity measurement tool for surveillance. There are some recommendations to be made regarding this measurement tool. First, it should be validated in the ethnic minority groups, not only for calculating recommended levels, but also for total score and component scores. The SQUASH was slightly adapted with an open-ended question and some extra physical activities. Less frequently used methods in cross-cultural validation of physical activity questionnaires are incorporating cognitive testing, testing the logical structure of the questionnaire, an introduction to certain questions or the questionnaire structure, and optimal probing methods (using written questions to remove interviewer bias) to stimulate an unbiased recall of self-reported physical activity levels, especially across ethnic groups. This would further advance our knowledge in physical activity and health research across ethnic groups.

**Part 5 - Main conclusions**

The aim of this thesis was to investigate ethnic differences in physical activity and their association with CVD and CVD-related risk factors in a population of European-Dutch, South Asian-Surinamese, and African-Surinamese ethnicity. The following main conclusions can be drawn.

First, physical activity patterns and types of activity differ between the ethnic groups, which results in ethnic differences in the contribution of certain domains of activity to the recommended level of physical activity. Therefore, especially across ethnic groups, an accurate identification of all domains and types of physical activity seems necessary to estimate ethnic differences in physical activity. In addition to accurately identifying physical activity (including total physical activity), an operationalization of physical activity that is sensitive to the outcome of interest is another important way to identify ethnic differences in physical activity, which we demonstrated for intensity of activity and blood lipids. These results suggest that to better understand ethnic differences in physical activity and cardiovascular health, both summary measures and volume measures of physical activity should be taken into account.

Second, in terms of the observed patterns of physical activity, the South Asian-Surinamese and African-Surinamese ethnic groups are less active compared to the European-Dutch ethnic group. This finding cannot simply be generalized to other ethnic minority groups in other countries, as the precise level and type of physical activity in ethnic minority
groups appeared to vary between countries, depending on the pattern of physical activity of the majority population. The cross-national comparison provides further insight into the influence of environmental differences on physical activity behavior and possible convergence in the ethnic minority groups. Such a cross-national approach has proven to be helpful in studying the effect of environmental differences on behavior, in this case physical activity.

Third, in terms of the relationship with health and recommendations for public health, ethnic minority populations might benefit from becoming more physically active as well. Our results suggest that the social patterning of physical activity in ethnic minority groups differs from that of the majority population. It is therefore important to stimulate physical activity while, because of expected changes over time, also monitoring which subgroups within the ethnic minority groups are at high risk of a certain type of physical activity behavior.

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