Author’s response to reviews

Title: Associations between neighborhood walkability and daily step counts in adults: A systematic review and meta-analysis

Authors:

Samantha Hajna (samantha.hajna@mail.mcgill.ca)
Nancy A Ross (nancy.ross@mcgill.ca)
Anne-Sophie Brazeau (anne-sophie.brazeau@mcgill.ca)
Lawrence Joseph (lawrence.joseph@mcgill.ca)
Kaberi Dasgupta (kaberi.dasgupta@mcgill.ca)

Version: 2 Date: 30 May 2015

Author’s response to reviews: see over
REVIEWER ONE

Comment # 1: The relation between walking and walkability measures is theoretically a good fit and this review and meta-analysis appear well-written. However, much depends on the accuracy of the measure for ‘walking’, and the accuracy of pedometers is quite varying from model to model. See e.g. Schneider et al 2003, Silcott et al 2011, Barriera et al 2013, Webber et al 2014 and Akerberg et al 2014. Are the step counts used in the 6 included articles valid and comparable? Does this influence your results? Something similar can be said for walkability; how comparable are the measures used in the 6 included papers? Making GIS measures comparable across countries is a huge effort, see e.g. Adams et al 2014 I think the authors need to address both these point more elaborate, both in their results as well as their discussion of study limitation.

Thank you for your comment. We agree that the comparability of both exposure and outcome measurement is important when pooling results across studies. Five of the six studies that we included in our review assessed daily step counts using pedometers. Three of these used Yamax pedometers and two of these used Omron pedometers. Although not all of the models were the same, they all captured step counts using comparable technology and each model has been shown to accurately capture daily step counts in adults (Schneider et al., Med Sci Sports Exerc. 2003;35(10):1779–84). Step counts were assessed in one of the six studies (Kondo, 2009) using accelerometers. The step counts function of this biosensor has also been validated (Schneider et al., Med Sci Sports Exerc. 2003;35(10):1779–84). In Table 1 we provide a summary of the types of biosensors that were used in each of the six studies and indicate the references to the papers in which the accuracy of these biosensors have been reported.

We agree that making GIS measures comparable across countries is a huge effort. As pointed out in the recent study by Adams and colleagues (2014), large between country differences exist in actual neighbourhood walkability. Further, between study differences exists in how walkability is measured and in the availability and quality of the spatial data that are used for the calculation of these measures. In our study, the bias arising from these differences was mitigated by the fact that we pooled relative estimates of walkability (i.e., high versus low walkable neighbourhoods) rather than absolute measures (e.g., residential density). Because of this, we believe that there is no important threat to the accuracy of the conclusions that we have drawn based on the pooled results. Further, when we selected articles into our study, we were careful to select studies that used comparable measures of walkability. All of the studies that we included in our study used comparable operational definitions for street connectivity, land use mix and/or residential density and used comparable methods of calculating these variables. Please refer to Table 2 for a summary of the operational definitions and data sources of each of the measures that were used in each of the studies that we reviewed. Nevertheless, to address the potential concern regarding the comparability of the exposure and outcome measures across the studies included in our study, we have, as you have suggested, added a discussion about this into the body of our manuscript. We now state the following in the manuscript:

“The measurement of daily step counts and neighbourhood walkability was comparable across all studies. Daily step counts were assessed using biosensors that have been validated for use in adults (37-43) and neighbourhood walkability was assessed using comparable operational definitions of street connectivity, land use mix, and/or residential density.” (Results; Lines 218 to 222)

“All of the studies that were retained in the meta-analysis assessed steps using tools that have been validated for use in adults – thereby increasing the comparability of the outcomes across the studies.” (Discussion; Lines 264 to 266)

Please note that these changes are also highlighted in the text.
<table>
<thead>
<tr>
<th>Study</th>
<th>Biosensor</th>
<th>Model</th>
<th>Validation Studies</th>
</tr>
</thead>
</table>

* Note: Validation conducted on the same brand of biosensor but on a different model.
Table 2. Comparability of the neighbourhood walkability measures (i.e., exposures) across studies.

<table>
<thead>
<tr>
<th>Study</th>
<th>Measures</th>
<th>Operational Definition</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kondo, 2009</td>
<td>Residential density</td>
<td>Number of households within 500-m radius around home</td>
<td>City GIS databases and in-field audits (for land use types)</td>
</tr>
<tr>
<td></td>
<td>Land use mix</td>
<td>Number of land use types within 500-m radius around home</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Street connectivity</td>
<td>Number of intersections and length of streets within 500-m radius around home</td>
<td></td>
</tr>
<tr>
<td>Van Dyck, 2011</td>
<td>Population density</td>
<td>Number of inhabitants in predefined neighbourhood per km²</td>
<td>Cadastral data</td>
</tr>
<tr>
<td></td>
<td>Street connectivity</td>
<td>Number of intersections in predefined neighbourhood per km²</td>
<td>Geographic map data</td>
</tr>
<tr>
<td>Dygryn, 2010</td>
<td>Residential density</td>
<td>Number of inhabitants in the 1000-m network buffer around home.</td>
<td>Permanent Residence Registration Office</td>
</tr>
<tr>
<td></td>
<td>Land use mix</td>
<td>(-1) Σ_k(p_klnp_k)/ln N where p was the proportion of land area devoted to the specific land use (k) in each buffer divided by ln(total number of land uses of interest). (Score: 0 to 1)</td>
<td>Land use plan data</td>
</tr>
<tr>
<td></td>
<td>Street connectivity</td>
<td>Number of intersections (of three or more roads) in the 1000-m network buffer around home.</td>
<td>Street graph of Olomouc</td>
</tr>
<tr>
<td>Van Dyck, 2009</td>
<td>Residential density</td>
<td>Number of households per km² in predefined neighbourhood</td>
<td>Geographic map data</td>
</tr>
<tr>
<td></td>
<td>Street connectivity</td>
<td>Number of intersections with three or more intersecting streets per km² in predefined neighbourhood</td>
<td></td>
</tr>
<tr>
<td>Robertson, 2012</td>
<td>Residential density</td>
<td>Dwellings per hectare in 400-m buffer around home</td>
<td>GIS datasets and digital maps</td>
</tr>
<tr>
<td></td>
<td>Land use mix</td>
<td>(-1) Σ_k(p_klnp_k)/ln N where p was the proportion of land area devoted to the specific land use (k) in each 400m buffer around home divided by ln(total number of land uses of interest). (Score: 0 to 1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Street connectivity</td>
<td>Number of intersections (of three or more roads) in the 400-m buffer around home</td>
<td></td>
</tr>
<tr>
<td>Zhang, 2014</td>
<td>Street connectivity</td>
<td>The number of street intersections divided by area km² within the 500-m buffer.</td>
<td>Roads and Traffic Authority data set</td>
</tr>
</tbody>
</table>

The walkability index also incorporated a measure of the Floor Area Ration (i.e., the ratio of retail area to the entire commercial area in the 1000-m network buffer around home.)

The walkability index was based on a total of 13 GIS-derived variables based on GIS datasets and digital maps.
Comment # 2: Line 198: ‘Daily step counts provide a good estimate of overall levels of walking’. This statement needs a reference.

In our original submission, we included all of the references at the end of the sentence:

“Daily step counts provide a good estimate of overall levels of walking, the preferred form of physical activity among adults that has been linked to important health benefits [9, 10, 19, 26].”

In the revised document, due to changes that were made based on the other reviewer’s comments, only the first portion of this sentence remains. We follow this sentence, as you advised, with the appropriate references:


The sentence now reads:

“Daily step counts as captured by these devices provide a good estimate of overall levels of walking (27, 28).”

(Introduction; Lines 154 to 155)

REVIEWER TWO

Comments on Abstract

Comment # 1: Results and conclusion are more or less the same.
Thank you for drawing our attention to this. Upon rereading the abstract, we agree that the conclusions and results are very similar. We have edited the abstract to better distinguish between the results and the conclusion sections, to more clearly address the implications of our findings, and to make recommendations for future research. The results and conclusions of the abstract now read as follows:

“The search strategy yielded 8,744 unique abstracts. Thirty of these underwent full article review of which six met the inclusion criteria. Four of these studies were conducted in Europe and two were conducted in Asia. A meta-analysis of the studies (n=4) in which comparable effect estimates were reported indicated that participants living in high compared to low walkable neighborhoods accumulate 766 more steps per day (95% credible interval 250, 1271). This accounts for approximately 8% of the recommended daily step counts.”

(Abstract Results; Lines 64 to 69)

“The results of European and Asian studies support the hypothesis that improving neighbourhood walkability may be lead to increases in overall levels of walking in adults. Studies on the association between walkability and biosensor-assessed walking are needed in North America.” (Abstract Conclusions; Lines 79 to 81)

Comment # 2: 65:“that have been done”: casual
This was edited out as a result of the revisions that were made in response to Comment #1.

Comment # 3: □67: may be associated
This was also edited out as a result of the revisions that were made in response to Comment #1.
Comments on Background

Comment # 4: Short and very superficial introduction. You could explain a bit more about walkability: what is walkability, how is it measured, e.g. street connectivity, land use mix.

Thank you for your comment. Our intention was to be concise, but not at the expense of coming across as superficial. To address your concern we expanded the introduction to include a more thorough explanation of neighbourhood walkability including how it is commonly measured and why we have focused specifically on street connectivity, land use mix and/or residential density. We have also inserted a more thorough explanation of why biosensor-assessed daily step counts were a particularly important outcome of interest. All of the changes that have been made are tracked in the manuscript (See Lines 101 to 160). Please note that we have also made a small change to the abstract’s introduction, in order to reflect the changes that we made in the main text.

Comments on MeSH Terms

Comment # 5: How far did you look back for articles, from which year?

We did a search on all articles that indexed in PubMed, SCOPUS, or Embase (Ovid) prior to May 20, 2014 (i.e., from 1946 for PubMed, from 1996 for SCOPUS, and from 1996 for Embase (Ovid)). We made this clearer in the methods section. We now state the following:

“A systematic search was conducted on titles, abstracts, keywords, MESH terms and/or subject headings, as appropriate, that were ever indexed in PubMed, SCOPUS, or Embase (Ovid) prior to May 20, 2014 (i.e., from 1946 for PubMed, from 1996 for SCOPUS, and from 1996 for Embase (Ovid)).” (Methods; Lines 165 to 168)

Comment # 6: Additional file is not really necessary as it is a very short piece of text, add it in the methods.

Thank you for this suggestion. We have now incorporated the search string directly into the text. We now state the following:

“The following search string was used: [physical activity OR walk OR walking OR pedometer OR acceleromet* OR exercise OR actigraphy OR actimetry] AND [built environment OR walkable OR walkability OR street connectivity OR land use mix OR residential density OR population density OR environment planning OR neighborhood OR home environment OR urban design OR environment design OR residence characteristics OR Geographic Information Sys* OR geographic mapping].” (Methods; Lines 168 to 174)

Comment # 7: ‘Actigraphy’ is mention twice. Change it to actigraph* instead of actigraphy, since this is the name of the measurement instrument, and therefore can also be used in articles.

Thank you for drawing our attention to this. This is a typographical error. There should be one entry for “actigraphy” and one entry for “actigraph”. This has been fixed in the text (See Lines 170).

Comment # 8: Why home environment?

While we acknowledge that the term “home environment” captured studies that assessed microenvironments (e.g., number of staircases in home) rather than the larger neighbourhood design variables that were interested in, we wanted to be conservative in our search criteria and include a larger number of studies to review rather than risk missing some important studies. Our rationale for doing this was that the term ‘home environment’ is similar to the terms “home neighbourhood” or “neighbourhood environment” and may have been used interchangeably by some researchers. Inclusion of the term “home environment” would not alter the final results and findings of our study.
Comment # 9: Add neighbourhood design to MESH terms, as environment design and urban design is also included.

Thank you for your suggestion. We decided not to include the term “neighbourhood design” as a MeSH term because it is not a designated term specified in the catalogue of the US National Library of Medicine. We also decided not to include it as a regular search term because we included the search term “neighbourhood” and we believed that any studies with the term “neighbourhood design” would have been identified by the “neighbourhood” search term anyways. Nevertheless, to address your concern and to verify our hypothesis, we reran the search with the “neighbourhood design” term included. As we expected, exactly the same number of articles were returned when including and not including this additional search term in SCOPUS and in Embase (Ovid).

Comment # 10: Land use mix, street connectivity, etc. are used as key words to search for articles. There is no explanation about these terms. Explain in the introduction or methods.

Thank you for your comment. Please see our response to Comment # 1. As you suggested, we have included definitions for street connectivity, land use mix and residential density in the introduction. This section now reads as follows:

“Street connectivity, land use mix and residential density are three large-scale features of neighbourhood designs that are commonly studied for their associations with physical activity (9-12). Street connectivity is defined as the number of three or more-way intersections per square kilometre within a neighbourhood buffer where a greater number of intersections are indicative of increased ease of movement between origins (e.g., residences) and destinations (e.g., shops and parks) (10, 13). Street networks of neighbourhoods with high intersection density are typically designed using a finer grid pattern and thus provide a more straight-line option of travelling from origins to destinations (13). In addition to this, high connectivity slows traffic as a result of multiple stopping sites and allows pedestrians to reach their destination via a variety of routes, potentially making non-motorized transport more appealing (11). Land-use mix is a measure of the number of different land uses located within a neighbourhood (10, 13). The more types of land uses that are contained within a neighbourhood, the more convenient it is for residents to walk to the services supplied by these areas (11). For example, in many downtown neighbourhoods, apartments are located above street-level shops and in close proximity to churches, schools and other services thus making walking to these destinations relatively easy. This is in contrast to newer suburban areas where there is a wide separation between residential and commercial land area making motorized transportation to points of interest a near necessity (13). There are several ways to calculate land use mix (14). The most common method is using the Shannon entropy score (11, 15). The score ranges from 0 to 1 where a higher score is indicative of greater heterogeneity in land uses within a neighbourhood (10). Residential density is defined as the number of residences per square kilometer of residential land area in the home buffer (12) or per square kilometer of the household’s dissemination block (10). A greater residential density is indicative of neighbourhoods in which there is a greater convenience for non-motorized transport as a result of there being more people to visit and a greater demand for accessible community, such as shops and parks (13). Street connectivity, land use mix and residential density are correlated (16). As a result, when estimating their associations with health outcomes, researchers commonly aggregate these measures into indices that capture neighbourhood walkability – that is, the degree to which a neighbourhood is “walking friendly” (11, 16).” (Introduction; Lines 114 to 142)
Comments on Methods

Comment # 11: Methods: All of the identified articles: how many? Clarify the searching strategy: How many articles left over after each selection step Mentioned in the results, but move to methods.

In keeping with standard reporting practices, we reported the results of the search in the results section (See the “Search Results” Subheading: Lines 211 to 213). This is in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). If the editor would like to make changes in this regard we would be happy to discuss this further. Please note that we have inserted a line into the methods section to reiterate that the standard guidelines for reporting and conducting the systematic review and meta-analysis have been followed. This statement reads as follows:

“The systematic review was conducted in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (28).” (Methods; See Line 164-165).

Comments on Methods

Comment # 12: 161: What about the other 3 studies? Are these the ones you mention next? Be clear: ... conclusive for three studies. The other three studies assessed ...

Thank you for drawing our attention to this. We acknowledge that this could have been stated more clearly. In our original submission we stated:

“The point estimates of all six studies suggested that higher walkability was associated with a greater number of daily step counts. Based on the confidence intervals, these associations were conclusive for three studies [13, 11, 14]. Three of the six studies assessed the role of walkability on utilitarian walking.”

We have updated this sentence to read:

“The point estimates of all six studies suggested that higher walkability was associated with a greater number of daily step counts. Based on the confidence intervals, however, these associations were conclusive for only three of these studies (29, 31, 32).” (Results; Lines 226 to 228).

Comment # 13: 162: Explain what utilitarian walking is.

Thank you for your comment. We did indeed neglect to define utilitarian walking. We now mention utilitarian walking in the introduction (as a result of the suggestions that you made in Comment #1) and provide a definition of utilitarian walking there. We state:

“Higher neighborhood walkability has been linked to higher levels of utilitarian walking (i.e., walking for specific purposes such as for going to school or going shopping) (19-22).” (Introduction; Lines 143 to 144).

Comment # 14: 166-167: No brackets, make it a sentence in the text.

We removed the brackets and made it a sentence in the text as you have suggested.

In the original submission we wrote:

“In the Japanese study, no important association was observed for utilitarian walking (Difference in time spent in utilitarian walking between adults living in high versus low walkable neighborhoods: -5 min/day; 95% CI -10 to 1) [16].”
We changed this to now read:

“In the Japanese study, adults living in high walkable neighborhoods reported walking 5 min/day less than people living in low walkable neighbourhoods (95% CI -10 to 1) (36).” (Results; Lines 233-235)

**Comments on Discussion**

**Comment #15:** Short discussion, is this a brief report? Line 194: Explain a bit more about these other ways of measuring walkability. Are there any limitations to your study? E.g. only 6 studies; not all the 6 were comparable with CI intervals; maybe some aspects of walkability could be important but not included in this study? Recommendations for future research?

Thank you for drawing our attention to this. As with the introduction, our intention was to be concise but not at the expense of coming across as superficial. We have taken your suggestions and expanded our discussion accordingly. We now more thoroughly explain the primary strengths of our study (i.e., it is the first to quantify the association between walkability and biosensor-assessed total walking AND the use of daily step counts as a measure of total walking). We also highlight the important study limitations, including the relatively small number of studies that were included in our study and the potential for a small bias arising from differences in how walkability was measured. In the conclusion we also make some recommendations for future research. All of the changes that have been made are tracked in the manuscript (See Lines 253 to 319).

Please note that we did not address two of the suggestions that you mentioned in Comment #15:

1. “Line 194: Explain a bit more about these other ways of measuring walkability.”
   
   We edited the paragraph that included this line in order to better address the novelty of our and, as a result, this line was removed. We felt that describing the other methods of measuring walkability would distract from the topic at hand. Instead, in the limitations we now state (as you suggested) that our study looked only at a specific component of walkability (i.e., macro-scale features of neighbourhoods) and that there are other components of walkability (i.e., micro-scale features such as neighbourhood safety) that may be associated with walking that were not captured in this study.

2. “Not all six studies had comparable CI intervals”
   
   We do not agree that this is a limitation. Variability in confidence intervals is expected and is characteristic of all meta-analyses. The confidence intervals will vary based on the true association observed in each population, the study population in which the study is being conducted, and the sample size of each study. When pooled estimate are calculated (in our case using a Bayesian normal-normal model), the variability in confidence intervals is accounted for in the statistical analysis.

**Other changes:**

1. For added clarity we added subheadings to methods section (search strategy, article review and data extraction, statistical analysis).

2. For added clarity we also added the step counts that correspond to the cutoffs that we described in our original submission (See Lines 278 to 280).

3. For added clarity and in keeping with the author guidelines specified in the BMC Public Health Guidelines for Authors available online, we have replaced the following sentence in the
methods section of the abstract: “A meta-analysis was conducted to determine the mean difference in daily step counts between adults living in high versus low walkable neighborhoods.” with “The mean differences in daily step counts between adults living in high versus low walkable neighborhoods were pooled across studies using a Bayesian normal-normal hierarchical model.”

References


