ASSOCIATION OF RESIDENTIAL GREENNESS WITH OBESITY MEASURES: A LITERATURE REVIEW

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ABSTRACT

Exposure to residential greenness has previously been associated with health and body weight outcomes, although inconclusively. We aimed to review available studies on the association of residential proximity to greenness and adiposity measures. We searched PubMed for studies published in English, without restriction referent to study design or sample's age, examining the relationship between exposure to greenness and obesity measures (either as primary or secondary outcomes). Residential greenness was assessed through the Normalized Difference Vegetation Index (NDVI). Combinations of the following keywords were used: NDVI and obesity, or overweight, or Body Mass Index (BMI). A total of 23 studies were retrieved. After elimination of duplicates, and scanning of the abstracts for relevancy with the subject, a sum of 12 studies were included in the present review. Ten studies had a cross-sectional design, and the remaining two were prospective. Sample sizes ranged from 102 to 387,195 participants, whereas the buffer zones for NDVI were within a 100-1000m radius from residence. Ten of the studies revealed an inverse relationship between proximity to greenness and adiposity measures (expressed as raw BMI values, presence of overweight and/or obesity, presence of abdominal obesity), and the remaining two showed no significant results. A sex-dependent relationship may also exist, with greenness inversely associating with obesity measures only in women. More prominent anti-obesity greenness influences were apparent, when smaller NDVI buffer zones (<400m) were employed. Closer proximity to greenness is beneficially associated with healthier body weight and adiposity indices. This review highlights the relationship of urban planning with population health, at the obesity epidemic level. Future studies on the area should also investigate the influence of accessibility, safety and aesthetics of the green areas.

KEYWORDS

Green space; Normalized Difference Vegetation Index; Overweight; Weight status

1. INTRODUCTION

The number of people with obesity has quadrupled from 1975 to 2014 [1], with over 600 million people worldwide now characterized as obese. Many personal factors, genetic and behavioral ones, contribute to the longitudinal accumulation of excess weight [2; 3]. Nevertheless, it seems unlikely that these influences could fully explain the dramatic rise of obesity at the global level, suggesting that environmental aspects may be of importance.

Towards this end, the influence of the built environment in adiposity measures has been examined. Exposure to green

spaces, i.e. access and/ or availability of areas with vegetation (parks, gardens, forests etc.), has been investigated as a potential factor that may affect obesity indices [4]. The results of relevant studies have been inconsistent though. For instance, while most studies support the benefits of exposure to greenness for many health outcomes, in relation to obesity, systematic reviews indicate a weak positive [5], or no association between greenness and excess body weight [6].

The inconsistency in the available information calls for further investigation in order to reach more robust conclusions. Our aim was to review available studies on the association between residential proximity to greenness and adiposity measures.

2. METHODOLOGY

We searched PubMed for studies published in English, without restriction referent to study design, publication date or sample's age. We searched for studies examining the relationship between exposure to greenness and obesity measures, with excess weight being either the primary or listed among the secondary outcomes. Residential greenness was assessed through the Normalized Difference Vegetation Index (NDVI). Combinations of the following keywords were used: NDVI and obesity, or overweight, or Body Mass Index (BMI). The reference lists of the retrieved studies were also scanned for relevant research

A total of 23 studies were retrieved. After elimination of duplicates, and scanning of the abstracts for relevancy with the subject, 12 studies were included in the present review. The descriptive characteristics of the studies are presented in Table 1.

3. RESULTS AND DISCUSSION

Ten studies had a cross-sectional design, and the remaining two were prospective. Sample sizes ranged from 102 to 387,195 participants, whereas the buffer zones for NDVI were within a 100-1000m radius from residence.

3.1 Studies in children and adolescents

Four of the retrieved studies examined the association of greenness with adiposity measure in paediatric populations, with sample sizes ranging from 102 to 79,992 participants. One study had a longitudinal design, and the rest were cross-sectional.

A large Spanish longitudinal study, that followed up around 80,000 children from birth to 5 years, concluded that children living closer to green spaces, or children having greater greenness exposure (measured by NDVI), exhibited attenuated BMI trajectories [7]. These associations were strongest in the first two months of life, indicating the influence of green spaces in body weight even in early life.

Two cross-sectional studies on pre-school, and school-aged children also reported similar findings. Petraviciene et al., found that lower NDVI within 100m from residence associates with increased odds of overweight/ obesity in children aged 4-6 years old [8]. In the study by Dadvand and associates, an interquartile range increase in NDVI, when measured 100-1000m from residence, was associated with 11-19% lower prevalence of overweight/ obesity in 3,178 children aged 9-12 years old [9]. Of note, this beneficial association was greater when smaller buffer NDVI zones were employed.

On the other hand, a small Mexican study reports no association between NDVI and BMI z-scores of pre-school children, whereas greater exposure to greenness,

and more time spent in green spaces was associated with increased moderate-to-vigorous activity levels [10].

3.2. Studies in adults

A sum of 8 studies in adults were reviewed, with sample sizes ranging from 529 to 387,195 participants. One study had a prospective design, and the rest of them were cross-sectional.

A large prospective Swedish study, with over 5,000 adult participants suggested that higher NDVI levels (within a 500m radius from residence) associated with reduced increments in waist circumference, and consequent decreased risk for the development of central obesity over the course of 9 years. However, these findings were significant only in women [11]. Of note, similar sex-dependent results were provided by the study of Nichani and associates [12]. In this cross-sectional study of 14,550 mostly middle-aged adults, higher NDVI within 400m from residence negatively associated with the prevalence of overweight, obesity and excess waist circumference, yet only in women.

A Spanish study in 2,345 adults, measuring NDVI within 300m from residence indicates that the association of surrounding greenness and excess body weight is either weak, or non-existent, given that the odds ratios for pooled overweight and abdominal obesity did not pass the significance threshold [excess weight: OR=0.99 (95% CI: 0.88, 1.11); abdominal obesity: OR=0.91 (95% CI: 0.79, 1.05)] [13].

Despite the mixed findings in the aforementioned studies, the remaining 5 studies pointed towards the same direction, that is a beneficial relationship of greater exposure to greenness with attenuated obesity indices [14; 15; 16; 17; 18].

3.3. Summary of findings

In sum, the majority of the reviewed studies suggest a positive association between exposure to greenness and healthier body weight status. This is in line with a systematic review and meta-analysis of 57 observational studies that supports that in 55% of the reviewed studies, a beneficial association was present [4]. A sex-dependent relationship may also exist, with greenness inversely associating with obesity measures only in women. More prominent anti-obesity greenness influences were apparent when smaller NDVI buffer zones (<400m) were examined.

The mechanisms driving the observed relationships are largely unknown; this is due to the mostly observational design of relevant studies, and the inability to draw causal relationships. However, one may speculate that living close to green spaces may contribute to increased opportunities for physical activity. In addition, green spaces are known to be assistive in reducing stress, and exposure to pollution and noise. All the above-mentioned have been known to associate with healthier body weight status [4].

4. CONCLUSIONS

Closer proximity to greenness is beneficially associated with healthier body weight and adiposity indices. This review highlights importance of urban planning on population health in general, and on obesity in specific. Future studies on the area should employ standardized approaches that would take also into account the potential role of accessibility, safety and aesthetics of the green areas.

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Table 1. Overview of the reviewed studies

Study, Setting	Sample	Design	Methods	Outcome(s)	Conclusion
Studies in children and adolescents					
de Bont et al., 2020 Spain	79,992 children, followed up from 0-5	Longitudinal	NDVI	BMI trajectories	Closer exposure to greenness and green spaces associates with less longitudinal BMI increase
Benjamin-Neelon et al., 2019 Mexico	102 children, 3-5 years old	Cross-sectional	NDVI	Physical activity BMI z-score	Greater time in greenspace associated with physical activity, but not BMI
Petraviciene et al., 2018 Lithuania	1489 mother-child pairs Children aged 4-6-years old	Cross-sectional	NDVI within 100m of residence	Excess body weight	Children from families living in areas with less greenness exposure, had higher odds ratios of being overweight/obese
Dadvand et al., 2014 Spain	3,178 children 9-12 years old	Cross-sectional	NDVI within 100, 250, 500 and 1000m from residence	Excess body weight	An interquartile range increase in residential surrounding greenness associated with 11-19% lower prevalence of overweight/obesity

Study, Setting	Sample	Design	Methods	Outcome(s)	Conclusion
Studies in adults					
Persson et al., 2018 Sweden	5,126 adults	Prospective, with a follow-up of 9 years	NDVI 100, 250 and 500m from residence	Markers of adiposity	Higher levels of residential greenness were associated with a reduced increase in waist circumference during follow-up and decreased risk for central obesity in the 500m buffer, only in women
Huang et al., 2020 China	24,845 adults	Cross-sectional	NDVI within 500m from residence	BMI Obesity Central Obesity	NDVI associated with lower odds of peripheral and central obesity Higher NDVI values were associated with lower BMI.
O'Callaghan-Gordo et al., 2020 Spain	2,354 adults, 20-85 years old	Cross-sectional	NDVI within 300m from residence	Excess body weight Abdominal obesity	Associations between surrounding greenness and excess weight/obesity were null or modest based on a 1 IQR increase in NDVI [excess weight: 0.99 (0.88, 1.11); abdominal obesity:

Study, Setting	Sample	Design	Methods	Outcome(s)	Conclusion
					0.91 (0.79, 1.05)
Nichani et al., 2020 USA	14,550 adults, 55±9 years old, 61% women	Cross-sectional	NDVI within 400m from residence	Overweight Obesity WC WHR	NDVI was negatively associated with overweight, obesity and excess WC, only in women
Klompmaker et al., 2018 The Netherlands	387,195 adults	Cross-sectional	NDVI within 300m from residence	Overweight	Decreased odds of being overweight in the highest NDVI quintile were observed. Associations were stronger for subjects living in less urban areas, and for the smaller buffers.
Sarkar C, 2017 United Kingdom	333,183 adults, 38-73 years old	Cross-sectional	NDVI within 500m from residence	BMI WC Whole Body Fat Obesity	An interquartile increment in NDVI greenness was associated with lower BMI, WC, as well as a reduced relative risk of obesity.
Pereira et al., 2013 Australia	10, 208 individuals, aged over 16 years old	Cross-sectional	NDVI	Overweight Obesity	Being in the highest tertile of mean greenness was associated with lower

Study, Setting	Sample	Design	Methods	Outcome(s)	Conclusion
					obesity [0.78 (0.69-0.89)], and pooled overweight rates [0.84 (0.76-0.92)].
Tilt et al., 2007 USA	529 adults	Cross-sectional	NDVI within 0.4 miles from residence	BMI	In areas with high accessibility, BMI was lower in areas that had high NDVI, or more greenness

NDVI, Normalized Difference Vegetation Index; BMI, Body Mass Index; WC, Waist Circumference; WHR, Waist to Hip Ratio