Loneliness and physical activity during a COVID-19 lockdown. A comparison of urban and rural areas in the Hanover Region.

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Abstract

There is a well-established relationship between loneliness, physical activity (PA), and neighborhood characteristics. However, the COVID-19 pandemic has reshaped the determinants of physical, mental and social well-being in urban and rural areas. This study evaluated the interplay between neighborhood characteristics, loneliness and PA in urban and rural areas of the Hanover Region.

The following research question has been posed: How are loneliness and physical activity associated with accessibility of green spaces, sport- and leisure facilities in urban and rural areas of the Hanover Region during COVID-19 lockdown times?

Primary data (n = 112) from an online questionnaire was analyzed using Spearman correlations to describe associations between loneliness, PA and neighborhood characteristics. A Mann-Whitney U test and a two-sample t-test were used to assess differences between loneliness and PA in urban and rural areas.

No associations were found between loneliness and physical activity, and between loneliness and accessibility of green spaces, sports- and leisure facilities. There were no associations between PA and accessibility of green spaces, sport- and leisure facilities, except for a weak positive association (r_s = .199, p = .075) between PA and travel time by bike.

Proximity of neighborhood facilities in pre-lockdown times reduces loneliness and is conducive to PA; this research does not provide supporting evidence for such associations during a pandemic lockdown.

1.1 Background

Lockdown measures and contact restrictions were implemented in early 2020 against further transmission of the new coronavirus Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV2). Germany, as one of the first countries with a sharply rising number of infections had an imposed lockdown from March 22 2020 until May 2020. In November 2020 a second wave of soaring total infection numbers higher than 2.1 million, and of 92,457 detected infections in one week (Müller *et al.*, 2021) prompted lockdown measures again continuing until June 2021. Globally, the lockdown measures have resulted in unprecedented social and spatial distancing. A call for "distant socializing instead" (Zaki, 2020) and warnings of a mental and physical health crisis from psychologists were issued as a response. Moreover, the World Health Organization (WHO) released a guidance statement pointing out the negative consequences of large-scale quarantine measures on mental health, founded on evidence from past coronavirus outbreaks (Müller *et al.*, 2021; World Health Organization, 2020). The implementation of lockdown measures drastically slowed down the global economy, but the individual freedom of travelling, and engaging in physical and social outdoor activities was also curbed.

Maintaining a stable social network, however, is crucial for one's mental health, one's quality of life (QoL) and well-being (van den Berg *et al.*, 2016). According to Bu, Steptoe and Fancourt (2020b), social isolation is recognized as a risk factor for experiencing loneliness, a substantially negative predictor of social well-being (Cacioppo and Patrick, 2009). Previous studies in Austria, the UK and Germany that assessed loneliness in national populations before and during lockdown periods emphasize higher risks and actual rates of loneliness during lockdown times for various sociodemographic groups: students, young adults (18-30 years), old adults (65+), women, urban residents; and various socioeconomic characteristics such as living alone, low income and education, both high number of children and lack of children (Bu, Steptoe and Fancourt, 2020b, Stolz, Mayerl and Freidl, 2021, Schafroth and Mickler, 2020).

Urban planners, researchers and policy advisors are increasingly interested in how human well-being is linked with the living environment (Cao and Zhang, 2016). A more holistic, urban sociological stance has supplemented the biomedical, individual-level way of explaining individual-level psychological phenomena

(Buecker and Ebert *et al.*, 2020). Van den Berg et al. (2016) show that both objective and perceived built environment (BE) characteristics are correlated with loneliness among elderly in urban environment. They emphasize the need for further research to explicate the link of objective BE characteristics with loneliness. Also, Grenade and Boldy (2008) argue, the evidence of elderly loneliness in urban and rural areas in comparison is ambiguous.

Furthermore, Frantal et al. (2020) provide empirical evidence that physical and social activity are related to lower levels of social isolation. Nevertheless, they stress the existing need for empirical evidence from residential areas of various degrees of urbanization (urban, semi-urban, rural). Physical activity (PA), known to be beneficial for well-being and both mental and physical health, was found to inversely affect loneliness (Lippke, Fischer and Ratz, 2021). In turn, perceived loneliness and decreased emotional regulation predict less engagement in physical activity (Hawkley and Cacioppo, 2010; Hawkley, Thisted and Cacioppo, 2009). Also, for physical activity the built environment has been found to be of considerable influence (Sallis James F. *et al.*, 2012). The provision of infrastructure such as green spaces and recreational facilities allows for a diverse range of physical activities that come at low cost to citizens living nearby. According to evidence from studies in US cities, high accessibility of recreational facilities is positively associated with physical activity, such as walking or bicycling (Sallis James F. *et al.*, 2012). Not only are urban dwellers able to engage in sports and other physical activities at green spaces, urban parks and sports facilities, but they also have opportunities to socialize and engage in activities together. However, these inferences draw on evidence from pre-pandemic times. Along with continuing trends such as the depopulation of rural areas and the diminution of available services for rural dwellers, and the urban rise of opportunities for jobs, services and other personal development on the other hand, lockdown measures during the SARS-CoV2 pandemic may have reshuffled the cards for the mental health of urban and rural dwellers.

1.2 Research objectives

The purpose of this study is to contribute to an understanding of the consequences lockdowns have for the health of urban and rural residents during the COVID-19 pandemic. Conducted during the second COVID-19 wave in Germany with lockdown measures in place, this study focuses on the links of loneliness and physical activity in urban and rural areas with accessibility to green spaces, sport- and leisure facilities. To date, no studies exist on a regional scale in Germany on such urban rural differences during lockdown times This study set-out to collect primary data with a survey, distributed in the Hanover Region in Northern Germany, to arrive at a better description of rural-urban disparities in terms of social, physical and emotional well-being in lockdown during the COVID-19 pandemic. In addition, this research contributes to the general understanding of the influences of neighborhood characteristics on loneliness and physical activity. This way, the current research can add to the evidence on which policy- and political decision making in future critical pandemic times should be based.

1.3 Research questions

From the abovementioned research objectives the following question is proposed:

- *How are loneliness and physical activity associated with accessibility of green spaces, sport- and leisure facilities in urban and rural areas of the Hanover Region during COVID-19 lockdown times?*

  To answer this question the following subquestions are raised:

- *Is there an association between loneliness and accessibility of green spaces, sport- and leisure facilities?*

- *Is there an association between physical activity and the accessibility of green spaces, sport- and leisure facilities?*

- *Is there an association between physical activity and loneliness?*

- *Are there any significant differences in levels of loneliness and physical activity between urban and rural areas?*

1.4 Case study area

The study is based on primary data collection by means of a survey, distributed in the Hanover Region in Northern Germany (Fig. 1). The Hanover Region comprises the city of Hannover which is the capital city of the county Lower-Saxony, and 20 surrounding municipalities. Stretching out on approximately 2,300 km², the region counts about 1.1 million inhabitants (Priebs, 2014). The city of Hanover, consisting of nearly 50% public green spaces has a self-claimed status to be among the greenest cities in Germany (Hannoversche Allgemeine, 2014; Kuczma *et al.*, 2019). Moreover, it ranks among the highest ratings for satisfaction with green spaces in Germany (Forsa, 2014). On a loneliness map of Germany from research conducted prior to the pandemic by (Buecker and Ebert *et al.*, 2020), the Hanover Region can be identified among the regions where high scores of loneliness cluster. Therefore, it provides an interesting case study for this regional-scale research.

Figure 1. *The Hanover Region with its 21 municipalities; and its location in Germany. Source: Wikipedia, 2021*

1.5 Outline

The following chapter explains the theoretical framework with the relevant concepts that are addressed in this study. Current evidence and its implications for this study are described. Chapter 3 covers the methodology in terms of the data collection instrument and data analysis. Chapter 4 presents and discusses the results in relation to the theoretical framework. Chapter 5 concludes the research and provides the limitations of this study along with recommendations for further research. In the appendices, the links to the survey, and all relevant statistical results in form of graphs, tables and charts are found.

2. Theoretical framework

2.1 Loneliness

Social isolation, "usually regarded as an objective state where an individual has minimal contact with others and/or a generally low level of involvement in community life" (Grenade and Boldy, 2008, p. 469), is recognized to be a risk factor for experiencing loneliness. The latter can be defined as "the feeling that one's social needs are not being met by the quantity or quality of one's social relationships" (Bu, Steptoe and Fancourt, 2020b, p. 31).

Loneliness has severe consequences for both physical and mental health. Studies point out that loneliness is as detrimental as smoking and obesity for one's physical health, and negatively affects both the immune and cardiovascular system (Tiwari, 2013). Furthermore, it is related to risks of various psychiatric diseases, such as depression, anxiety, dementia, and suicidal ideation (Banerjee and Rai, 2020). A meta-analysis by Holt-Lunstad et al. (2015) emphasizes that loneliness is connected to a 27% higher incidence of overall mortality. Lauder et al. (2006) found supporting evidence for such associations, as in their study cross sectional survey data revealed that lonely individuals are less motivated to lose weight by walking activities.

Furthermore, Banerjee (2020) stresses the vicious cycle of experiencing loneliness and further limiting social interaction by withdrawal from social integration into isolation. Social isolation and loneliness are to be treated as different concepts, but are related and mutually reinforce each other (Sunwoo, 2020).

There is no consensus on the significant factors that make people more vulnerable to loneliness during lockdown times, but possible urban and rural differences in this respect have been marked as a research gap (Bu, Steptoe and Fancourt, 2020b; Buecker and Ebert *et al.*, 2020). In a study (Buecker and Ebert *et al.*, 2020) comparing regions in Germany before the pandemic, no significant association was found between living in urban or rural areas and loneliness. However, the less densely populated East Germany scored higher on loneliness levels than West Germany. Therefore, they conclude that the spatial variations found in their research are unlikely to be explained only by individual-level factors. Their study however does not investigate differences and associations on a smaller scale or within a region.

Besides, evidence for negative or positive changes of loneliness during lockdown times of the COVID-19 pandemic is mixed (Buecker and Horstmann *et al.*, 2020). Buecker et al (2020) found no linear increase in loneliness after introduction of lockdown measures, but rather an increase positively correlated with age. However, increasing levels of loneliness in Germany during the first lockdown in Germany were found in two other studies. Wirth (2020) points out that a remarkable proportion of 80% of adults (n=1000) indicated to have missed contact with friends and family in a German study. Schafroth and Mickler (2020) show results (n=1000) that suggest every second German resident has felt lonely during the first lockdown.

2.2 Physical Activity

Physical activity (PA) is an important determinant for both physical and mental health (Guthold *et al.*, 2018). Research during the COVID-19 pandemic has found physical inactivity to be a risk factor for

hospitalization upon contraction of the novel SARS-Cov 2 virus. Besides, a recent study from Germany based on data prior to the pandemic found PA to inversely influence loneliness (Lippke, Fischer and Ratz, 2021).

As discussed in a recent study by Moreno-Llamas, García-Mayor and La Cruz-Sánchez (2021), the WHO guidelines state that physical inactivity has increased globally in the 21st century. (Guthold *et al.*, 2018) found a prevalence of 36.8% in high-income countries (40.0-49.9% in Germany) in 2016. Over the last two decades, PA in the European Union has decreased in both urban and rural areas, with a stronger decline in the latter. The study concludes that living environments and regional urbanization play a minor role. Another study has found PA adherence to guidelines of the Centers for Disease Control and Prevention (at least 150 minutes of moderate or 75 minutes of vigorous PA) to be 42.6% in Germany during lockdown. Yet, overall research of rural PA is scarce.

Limited active mobility and hence limited PA adversely influence health and well-being, especially among the elderly (Sunwoo, 2020, Tsunoda *et al.*, 2015). On the other hand, being healthy, volunteering and socially active were found to be associated with a low risk of loneliness (van den Berg *et al.*, 2016). In line with this, Weijs-Perrée et al. (2015) found that walking increases social satisfaction and cycling positively influences the frequency of social interactions.

2.3 Urban and rural areas

General trends of demographic change in rural areas due to rural urban migration, with especially young people moving to urban areas for career and personal development opportunities, continue to alter the living conditions for rural inhabitants. (Moreno-Llamas, García-Mayor and La Cruz-Sánchez, 2021). Besides, poorer infrastructure and long distances, dispersal of health care amenities, and lower accessibility of public services may hamper social interaction and leave especially older rural dwellers disadvantaged. However, the strong and stable community networks of rural dwellers may attenuate loneliness (Menec *et al.*, 2019). Findings concerning PA in urban and rural areas are mixed (van Dyck *et al.*, 2011). Urban areas provide more incentives for transport-related PA, while in rural areas domestic and household-related PA is more common.

2.4 Accessibility of green spaces and sport and leisure facilities

Accessibility to green spaces is associated with reduction of loneliness and depression risk (Domènech-Abella *et al.*, 2020). Research by (Buecker and Ebert *et al.*, 2020) found significant levels of loneliness for individuals that cannot reach sport and leisure facilities within 20 mins on foot. However, their findings are based on large-scale pre-pandemic data. Evidence for COVID-19 lockdown times on a smaller scale and from within a region is still lacking.

2.5 Conceptual model

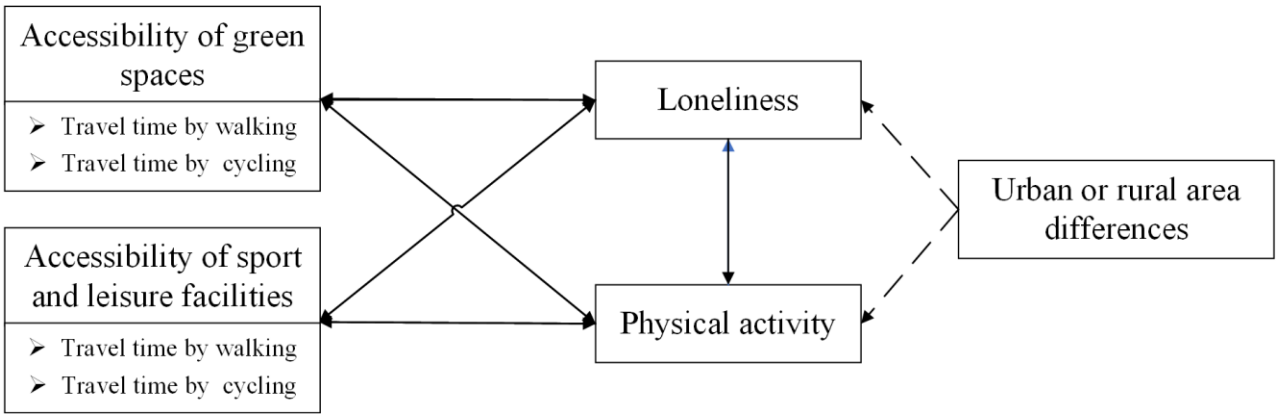

Figure 2. *Conceptual Framework with hypothesized links.*

3. Methodology

In this section, the data collection instrument, the survey distribution and ethical considerations, and the data analysis methods are discussed.

3.1 Data collection instrument

To answer the research questions, a primary data collection instrument was designed in form of a 24-item online survey questionnaire using Google Forms (see Appendix A). As the inhabitants of the Hanover Region are primarily German native speakers, the operating language was German. In the appendix both the English and German versions of the questionnaire can be found. Throughout this paper the English versions of the questions will be mentioned.

Based on factors associated with loneliness and physical activity in previous literature findings (Bu, Steptoe and Fancourt, 2020b; Moreno-Llamas, García-Mayor and La Cruz-Sánchez, 2021; van den Berg *et al.*, 2016), respondents were asked for their gender, age, household type, building type, and residence length. However, these data were not used for any analysis in this research but instead can be used in further research.

3.1.1 Loneliness

Operationalization of loneliness in questionnaires is usually undertaken through two different methods (Pinquart and Sorensen, 2001). The first understands loneliness as a unidimensional concept and asks explicitly for a feeling of loneliness. However, a shortcoming of this method is that respondents might be less inclined to admit to such direct and negatively connotated question containing the word ‘loneliness’. The other method makes up for this weakness in defining loneliness as a multidimensional concept with several items. The most commonly used scales are the UCLA Loneliness Scale (Russell, 1982) and the De Jong-Gierveld Loneliness Scales (Jong Gierveld and van Tilburg, 2010; Jong-Gierveld and Kamphuls, 1985; van den Berg *et al.*, 2016).

For this survey the validated 3-item UCLA Loneliness Scale (Hughes *et al.*, 2004) was adapted. Respondents were asked to answer the following three questions considering the current lockdown times: (1) how often do you feel that you lack companionship, (2) how often do you feel left out, (3) how often do you feel isolated from others. On a 3-item LIKERT scale the respondents could choose from ‘hardly ever or never’

(0 points), ‘some of the time’ (1 point), or ‘often’ (2 points). The total sum of the items yielded the total score per respondent with a range from 0 to 6. A score of 2+ defined loneliness, in accordance with previous research (Victor and Pikhartova, 2020).

3.1.2 Physical activity

An internationally validated instrument for measuring and comparing PA is the International Physical Activity Questionnaire (International Physical Activity Questionnaire, 2020). It is available in long versions with four domains of PA (work-related, transportation, housework/gardening and leisure-time activity) and items relating to sedentary activities, and short versions with four generic items. For this survey a German short version (International Physical Activity Questionnaire, 2020; Kajosaari and Laatikainen, 2020) was adopted and modified to a shorter, more simple and comprehensible 3-item version concerning walking, cycling, and other physical activities and exercises. The collected data served to gauge the total PA undertaken in a seven-day week during lockdown, expressed in a MET (Metabolic Equivalent Task) energy expenditure estimate. Respondents were asked to indicate how many days in a usual week during lockdown they spent at least 10 minutes on each of the following activities: (1) walking, (2) cycling, (3) other physical activities or exercises. A follow-up question asked to indicate the hours spent doing each of the three types of activity on one of those days. The official IPAQ scoring protocol (International Physical Activity Questionnaire, 2005) was followed to calculate the weighted MET-minutes per week by multiplying the duration (minutes), frequency (days) and the respective MET intensity, and summing up the respective scores for the three PA domains. The MET intensities for the domains walking (3.3) and moderate (4.0) PA of the official scoring protocol were adopted. For the domain other physical activities and exercises the intensity factor 6.0 was chosen, as this domain includes moderate (4.0) and vigorous (8.0) PA. To evaluate the differences between total PA in urban and rural areas, Median MET-minutes/week and interquartile ranges will be reported.

3.1.3 Urban or rural area

To assess whether a respondent lived in an urban or rural area, the respondents were asked for their zip code, the name of their city district or village (optional), and whether they live in a city/town or a village (respondents were asked to check ‘city/town’ for places above 5000 inhabitants). Previous research by (Ströbele and Hunziker, 2017) has pointed out the overestimation of rural inhabitants due to the experience that peri-urban (peripheral, remote settlements that are part of metropolitan areas but located between cities and the countryside) inhabitants tend to identify as rural inhabitants. To mitigate such overestimation, all three items were evaluated and a decision to categorize the respondent into either urban or rural home was made based on official data from the municipalities, towns and the Hanover Region (City Population, 2020; Hannover.de, 2021).

3.1.4 Accessibility of green spaces and sport and leisure facilities

Accessibility of green spaces and accessibility of sport and leisure facilities were both measured in travel time by walking and by bicycle. Respondents were asked how long it would take them to get to the nearest of each facility by walking and by bicycle. To make the estimation more convenient, respondents could choose from (1) 1-5 mins, (2) 6-20 mins, or (3) more than 20 mins, resulting in ordinal variables.

3.2 Survey distribution and ethical considerations

The survey was distributed directly via email and social media accounts to 300 individuals within the Hanover Region. Due to the concern for the validity and representativeness of responses that are acquired by virtual snowballing, public posts on social media accounts were not made to minimize the chances for any

shortcomings of the data quality. However, all individuals that received the survey were told to forward it to their friends in order to gain a larger sample size.

With regards to the power relations between researcher and respondent, there were no issues as filling out the questionnaire was voluntary and undertaken online without the presence of the researcher. For safeguarding of their privacy, respondents were informed that their data would remain completely anonymous and that no answers could be traced back to individual identities. The name of city district/village question was left optional and the items age, residence length and accessibility of green spaces and sport and leisure facilities were measured at an ordinal scale instead of ratio. This way, respondents could be more assured that their information could not be traced back to their identity. However, this compromised the accuracy of the data. An optional field was provided for leaving remarks and recommendations.

3.3 Data analysis methods

Microsoft Excel was used to identify and remove invalid responses. These were identified by distinguishing respondents from outside the Hanover Region. Moreover, an optional feedback field at the end of the survey helped to identify respondents that had not answered particular questions correctly. All responses that indicated a higher travel time by bike than on foot were invalidated. From 125 gathered responses within a period of 13 days (March 31, 2021 until April 12, 2021), a convenience sample of $n = 112$ valid responses could be created. Furthermore, for PA the data cleaning instructions of the IPAQ scoring protocol were followed. Responses that indicated 'N/A' for the time spent engaging in any domain of PA were excluded from the analysis. The invalidation of 31 responses resulted in a total number of $n = 81$ valid responses for PA.

The dataset was organized into variables with numerical codes and was imported to SPSS. Anonymous respondent IDs were created and the variables were organized into ordinal and nominal variables. Descriptive statistics were displayed and using frequency tables and histograms. According to the ordinal and ratio measurement types of the variables, Spearman's rho correlation test was chosen to evaluate correlations between loneliness and PA, and of these with walking and cycling time to green spaces, and walking and cycling time to sport and leisure facilities. The test indicates the strength of a relationship and whether it is positive or negative. Furthermore, a Mann-Whitney U test was chosen to examine whether there is a difference in loneliness between urban and rural areas of the Hanover Region. To assess the differences between PA in urban and rural areas, a two samples t-test was chosen. A Shapiro-Wilk test for normality showed a non-normal distribution of PA (see figure X) with a positive skewness (1.437) and a positive kurtosis (1.877). Yet, the number of cases was sufficient ($n > 30$) to carry out a parametric test.

4. Results

4.1 General

Of the 112 respondents, 61 (54.5%) lived in an urban area, and 51 respondents (45.5%) lived in a rural area. Most of the respondents reported a high accessibility to green spaces, sport- and leisure facilities, with a mode travel time of 1-5 mins by walking and cycling. All descriptive statistics and graphs of the sample variables are displayed in Appendix B.

4.2 Loneliness

Out of 112 respondents in the Hanover Region, 43 (38.4%) were categorized as lonely. With median and mode scores of 2, the majority of the respondents were classified as not lonely and indicated to hardly ever/never or only sometimes have felt lonely during a week in lockdown times.

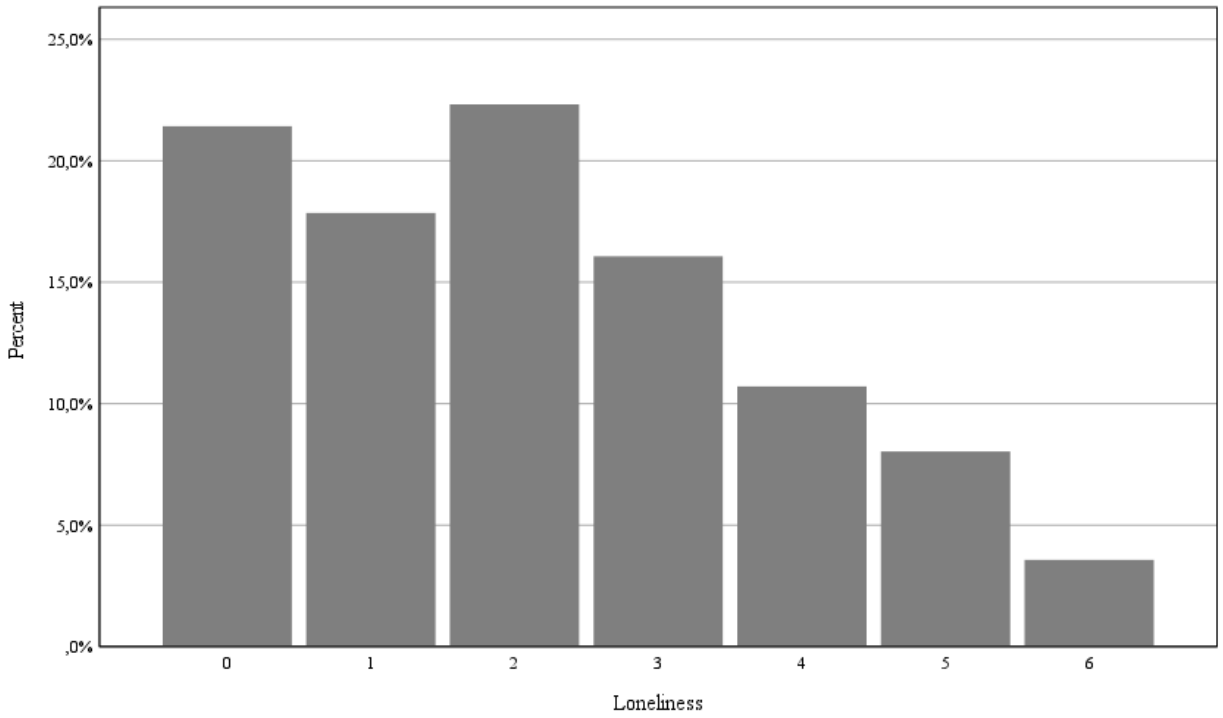

Figure 3*. Distribution of loneliness scores, UCLA-Scale (n = 112)*

4.2.1 Urban rural differences in loneliness

Concerning differences in loneliness in urban and rural areas of the Hanover Region, the median loneliness score of loneliness was higher for urban areas (*Mdn* = 2), than for rural areas (*Mdn* = 1). Furthermore, the mode score was also higher for urban areas (*Mode* = 2) than for rural areas (*Mode* = 0). More respondents from rural areas (14 respondents; 27.5%) than from urban areas (10 respondents; 16.4%) indicated to never or hardly ever feel lonely during the lockdown (see Table 2). However, higher scores of loneliness were more prevalent in rural areas than in urban areas (see Figure 4).

The results of the Mann-Whitney U test yielded an insignificant difference between rural homes (Mean Rank = 52,34, *n* = 51) and urban homes (Mean Rank = 59,98, *n* = 61), *U* = 1343.500, *z* = -1.259, *p* = .208. Hence, these results suggest that there is no significant difference in loneliness between urban and rural areas during lockdown times.

Table 2.

Differences in loneliness between urban and rural areas (n = 112)

			Urban or rural area		
			Urban	Rural	Total
Loneliness	0	Count	10	14	24
		% within Urban or rural area	16,4%	27,5%	21,4%
	1	Count	8	12	20
		% within Urban or rural area	13,1%	23,5%	17,9%
	2	Count	17	8	25
		% within Urban or rural area	27,9%	15,7%	22,3%
	3	Count	15	3	18
		% within Urban or rural area	24,6%	5,9%	16,1%
	4	Count	5	7	12
		% within Urban or rural area	8,2%	13,7%	10,7%
	5	Count	3	6	9
		% within Urban or rural area	4,9%	11,8%	8,0%
	6	Count	3	1	4
		% within Urban or rural area	4,9%	2,0%	3,6%
Total		Count	61	51	112
		% within Urban or rural area	100,0%	100,0%	100,0%

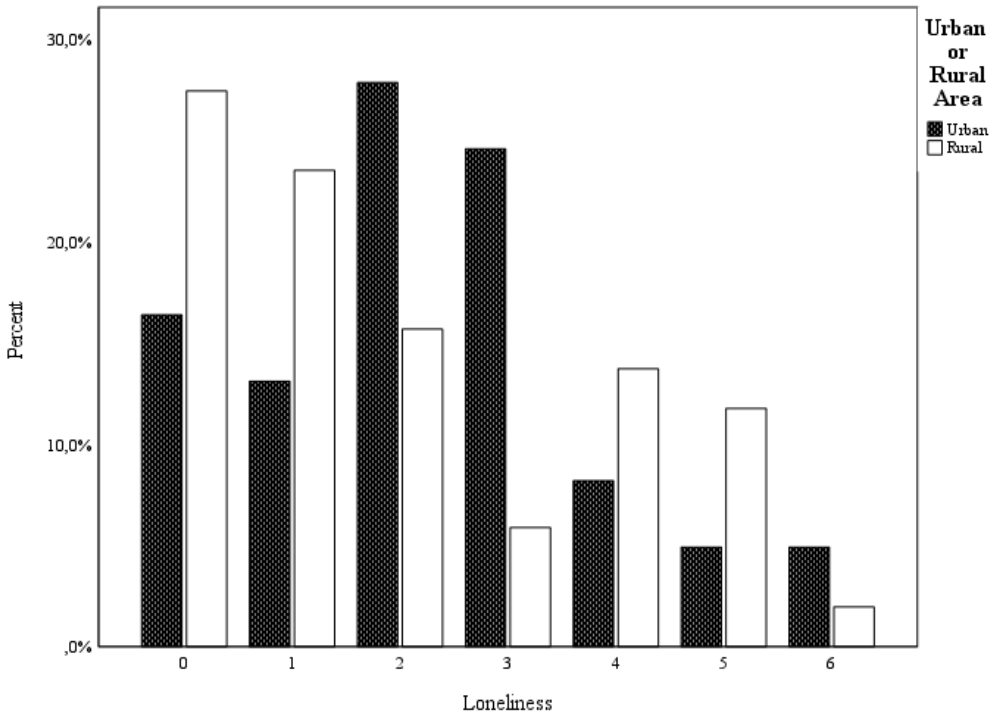

Figure 4. Percentages of loneliness scores in urban and rural areas

4.2.2 Loneliness and accessibility of green spaces, sport- and leisure facilities

A Spearman's rho correlations showed no significant associations between loneliness and walking time to green spaces (r_s = .086, p = .370,), loneliness and cycling time to green spaces (r_s = .142, p = .136), loneliness and walking time to sport and leisure facilities (r_s = -.050, p = .601), and loneliness and cycling time to sport and leisure facilities (r_s = -.045, p = .634). For a complete overview of all correlations, see table 3. With very weak signs of association, these results suggest that there is no association between loneliness and accessibility of sport and leisure facilities by walking and cycling in the Hannover Region during lockdown times.

4.2.3 Loneliness and physical activity

Regarding the association between loneliness and PA, the Spearman's rho correlation yielded an insignificant correlation r_s = -.110, p = .329, n = 81. Therefore, with a weak sign of a negative association, these results suggest that there is a no association between loneliness and PA.

Table 3.

Correlations

		Loneliness	Physical Activity
Walking time to green spaces	Correlation Coefficient	.086	.036
	Sig. (2-tailed)	.370	.749
	N	112	81
Cycling time to green spaces	Correlation Coefficient	.142	.135
	Sig. (2-tailed)	.136	.229
	N	112	81
Walking time to sport and leisure facilities	Correlation Coefficient	-.050	.171
	Sig. (2-tailed)	.601	.128
	N	112	81
Cycling time to sport and leisure facilities	Correlation Coefficient	-.045	.199
	Sig. (2-tailed)	.634	.075
	N	112	81
Loneliness	Correlation Coefficient		-.110
	Sig. (2-tailed)		.329
	N		81

4.3 Physical activity

All of the respondents (n = 81) reported they had engaged in at least 10 minutes of PA in a week during lockdown times. The mean PA in the Hanover Region was 2181.74, the median was 1644.75 and the interquartile range was 2101.00 METs per week. Of 81 respondents, 55 (67.9%) met the CDC recommendations of completing at least 150 minutes of moderate activity or 75 minutes of vigorous activity per week (Centers for Disease Control and Prevention, 2021).

4.3.1 Urban rural differences in physical activity

Mean PA scores were higher in rural areas (2247.06 MET) than in urban areas (2121.08 MET). Also, the interquartile range of PA was higher for rural respondents (2112.50) than for urban respondents (2054.88 MET). However, median PA was higher in urban areas (1817.00) than in rural areas (1462.00). See figure 5 for the median and IQR differences. The adherence to CDC recommendations of at least 150 minutes of moderate or 75 minutes of vigorous activity was slightly higher for rural respondents (27; or 69.2% of n = 39) than for urban respondents (28; or 66.7% of n = 42). The two sample t-test showed no significant difference ($t(79) = -.321$, $p = .749$) between rural homes (M = 2247.064, SD = 1933.276) and urban homes (M = 2121.077, SD = 1598.760). This suggests no significant difference in PA between urban and rural areas of the Hanover Region during lockdown times.

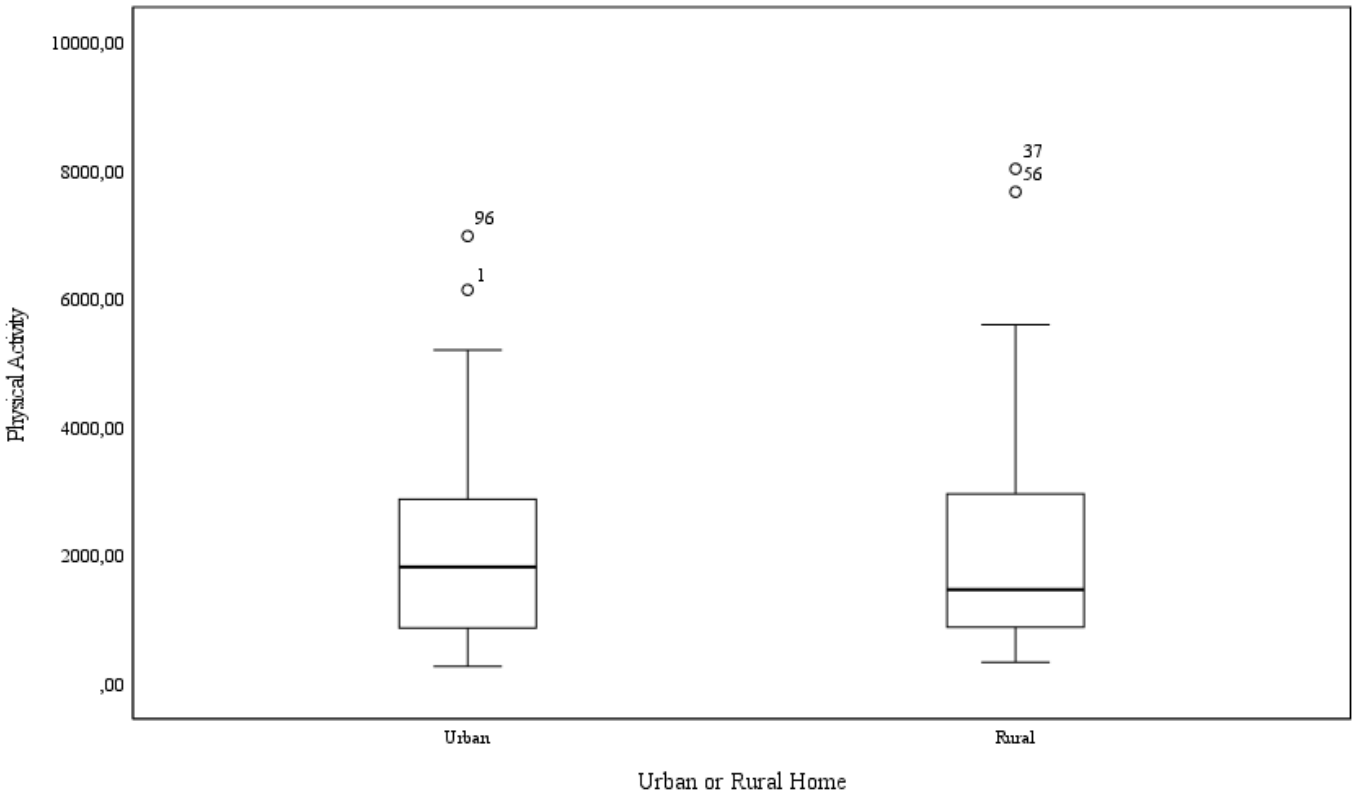

Figure 5. *Median and interquartile range differences of urban and rural PA*

4.3.2 Accessibility of green spaces and sport and leisure facilities

The Spearman's rho correlation showed no significant associations between PA and walking time to green spaces (r_s = .036, p = .749), PA and cycling time to green spaces (r_s = .135, p = .229), and PA and walking time to sport and leisure facilities (r_s = .171, p = .128). A significant, weak, positive association at a confidence level of α = 90% was found between PA and cycling time to sports and leisure facilities (r_s = .199, p = .075). Hence, these findings suggest that participants that had a longer travel time by cycling and hence lower accessibility of sports and leisure facilities by cycling also engaged in more PA or vice versa.

5. Discussion

No significant differences in loneliness between urban and rural areas during lockdown times were found in this study. This result suggests that variations of loneliness within a region are better explained by more context-dependent factors than the degree of urbanization. This is in line with the findings of (Buecker and Ebert *et al.*, 2020), who found no significant urban-rural differences in loneliness in a regional comparative study of Germany. However, their research was based on data comprising all regions of Germany before the COVID-19 pandemic. Research during the first lockdown in the UK (Bu, Steptoe and Fancourt, 2020a; Bu, Steptoe and Fancourt, 2020b) showed a higher risk and actual levels of loneliness for urban dwellers, which contradicts the findings of this current research. Moreover, living with others in rural areas, having close friends and social support were found as preventive factors against loneliness. While there may be less diversity of social contacts in rural areas than in urban areas, the strong ties to neighbors and other village inhabitants may provide more meaningful and stable social interactions, thus attenuating loneliness. Such relationships

are more persistent and amenable to less fluctuations. (Mair and Thivierge-Rikard, 2010) point out, that the frequency of social contact with neighbors, friends and relatives is more meaningful for subjective well-being of rural dwellers than for urban inhabitants. On the other hand, due to the continuing patterns of urban migration and socioeconomic reorganization, especially older rural dwellers may find less social support (Herron *et al.*, 2021). However, these arguments are not backed with evidence from this current study on a regional level.

Concerning the insignificant, very weak correlation between loneliness and accessibility of green spaces, sport- and leisure facilities, the findings of this current study contradict the evidence from (Buecker and Ebert *et al.*, 2020). They found accessibility of green spaces, sport- and leisure facilities to inversely affect loneliness in Germany. Notably, in this current study the very weak signs of association with walking and cycling time to green spaces were positive, which would suggest more loneliness with increasing travel times. If this is not merely attributable to chance, this would be in line with (Buecker and Ebert *et al.*, 2020). However, the insignificant results render it unfeasible to infer any correlation from the present results. Noteworthy, in the Hannover Region indoor sports facilities such as gyms and tennis courts had to close due to lockdown measures in place. As the data collection was administered in March, both fear of the virus and weather conditions may have limited frequenting green spaces, sport- and leisure facilities, and thus social interaction. Feelings of loneliness may therefore not be attenuated by mere accessibility of green spaces, sport- and leisure facilities.

Furthermore, there was no association found between loneliness and PA. Although being an insignificant result, the sign of a negative association would match with the findings of (Lippke, Fischer and Ratz, 2021), who found physically active students in Northern Germany to feel less lonely during COVID-19 lockdown times. As they conclude, physical activity can be seen as a modest but possibly effective factor to counter loneliness. They point out that especially during a lockdown, the engagement in team sports and other PA including social activity may provide a valuable coping strategy for loneliness and mental health problems. Although this seems like an appropriate inference, this current study suggests no association between loneliness and PA in the Hannover Region during lockdown times. As research by (Bu, Steptoe and Fancourt, 2020b; Buecker and Horstmann *et al.*, 2020) during a first lockdown indicates, other factors such as living alone, without children or being a parent may be more explanatory for loneliness during lockdown. Further research is needed that focuses on loneliness in relation to sociodemographic and socioeconomic predictors in combination with individual-level health characteristics such as PA.

PA levels were not significantly different between urban and rural areas in this study. The adherence to CDC guidelines in this current study (67.9%) was higher than the national average (42.6% of n = 1034) from another German study during the first lockdown (Maertl *et al.*, 2021). Furthermore, no differences in PA between urban and rural areas were found in this current study. Publications from the USA suggest an urban-rural PA gap with more inactivity in rural areas (van Dyck *et al.*, 2011). However, in Europe, where distances to facilities are shorter and road networks in rural areas are sufficient in many countries for other modes than the automobile, this gap is less prominent. Different neighborhood features of urban and rural areas were explored in context with urban and rural areas in Germany by (Markevych *et al.*, 2016). They found higher PA levels for females and urban dwellers that lived in areas with a higher green space percentage. Moreover, the presence of sports facilities in urban neighborhoods and the presence of leisure facilities in rural neighborhoods were associated with higher PA levels. In this current study, no associations were found between PA and accessibility of green spaces, sport- and leisure facilities except a weak association between higher PA and cycling time to sport-and leisure facilities (r_s = .199, p = .075). However, it seems counterintuitive to infer that a longer travel time is generally conducive to PA. Transport-related PA might be higher if one deliberately chooses to use active travel modes to reach sport- and leisure facilities. However, this would more likely be attributable to psychosocial factors such as self-efficacy and perceived barriers (van

Dyck *et al.*, 2011). Therefore, no association between PA and accessibility of green spaces, sport-, and leisure facilities can be inferred from the findings of this current study.

6. Conclusion

The aim of this study was to arrive at a better description of rural-urban disparities in terms of social, physical, and emotional well-being in lockdown during the COVID-19 pandemic. Moreover, this study contributed to an understanding of the influences of neighborhood characteristics on individual-level factors of well-being. Primary survey data (n = 112*)* was used for cross-correlations between loneliness and PA, and correlations with accessibility of green spaces, sport- and leisure facilities. Moreover, differences in loneliness and PA between urban and rural areas of the Hannover Region were assessed by a Mann-Whitney U test and a two samples t-test.

The insignificant results of the correlations suggest that there is no association between loneliness and accessibility of green spaces, sport- and leisure facilities in the Hanover Region during a COVID-19 lockdown. Furthermore, no supportive evidence could be found for any association between loneliness and PA, and between PA and accessibility of green space, sport- and leisure facilities. Although a weak, positive association between PA and travel time by cycling to sport and leisure facilities was found, it seems counterintuitive to assume that longer travel distances stimulate PA during lockdown. Levels of loneliness and PA were not significantly different between urban and rural areas of the Hanover Region during lockdown.

These findings suggest that during an imposed COVID-19 lockdown accessibility of green spaces, sport- and leisure facilities may no longer provide mitigating and preventive effects against loneliness. Similarly, these neighborhood characteristics may no longer sufficiently promote PA during lockdown. The official appeal to stay at home and keep social distance may have made it more difficult to engage in physical and social activities at public green spaces, sport- and leisure facilities. From the absence of urban rural disparities of loneliness and physical activity during lockdown in the Hannover Region it is reasonable to infer that a focus on micro-level neighborhood characteristics such as walkability and social cohesion may provide more insights into the geography of loneliness and PA during a lockdown.

6.1 Limitations and recommendations for further research

This study has several drawbacks. Firstly, the limited sample size (n = 112) makes drawing conclusions for the Hanover Region as a whole difficult. Secondly, the use of a self-administered survey may have led to recall bias. Additionally, possible honesty concerns due to the lockdown measures may have biased the responses. Loneliness was assessed in a short form, and elderly residents not capable of completing online surveys and other possible risk groups for loneliness (van den Berg *et al.*, 2016) were not included. Furthermore, the use of self-reported survey data for PA may have resulted in an overestimation of PA levels (Kajosaari and Laatikainen, 2020). This overestimation possibly has been further induced by asking for ‘other physical activities or exercises’ to group moderate and vigorous PA together for simplification. Researchers are advised to adhere to the IPAQ guidelines and the question formulations used therein in order to ensure data accuracy. Thirdly, objective measures of PA and accessibility to neighbourhood facilities should be incorporated to compare the results of this study in times without imposed COVID-19 lockdowns. A regression analysis with the collected sociodemographic data (see Appendix A) can provide insights into any possible causal relationships. Further research should take into account multiple variables, such as socioeconomic factors, income and education to compare loneliness in urban and rural areas in order to arrive at conclusions about the risk factors and causal relationships.

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8. Appendix A

8.1 Link to the survey (English)

https://docs.google.com/forms/d/e/1FAIpQLSfkXASVyHZVj3QgBdhzha35C3RaJUVWxIjy0MUhGvvXGVZ8lQ/viewform?usp=sf_link

8.2 Link to the survey (German)

https://docs.google.com/forms/d/e/1FAIpQLSd0HnA8jRVBAQnZHD6JV145rMBh52kAypZR6LSj4iJW4JZWUw/viewform?usp=sf_link

9. Appendix B

9.1 Statistical results

Table B1

Neighborhood characteristics (n = 112)

	N	%	Mode
Neighborhood characteristics			
Urban or rural area			
Urban	61	54.5	Urban
Rural	51	45.5	
Walking time to green spaces			1-5 mins
1-5 mins	79	70.5	
6-20 mins	25	22.3	
More than 20 mins	8	7.1	
Cycling time to green spaces			1-5 mins
1-5 mins	97	86.6	
6-20 mins	14	12.5	
More than 20 mins	1	.9	
Walking time to sports and leisure facilities			1-5 mins
1-5 mins	53	47.3	
6-20 mins	50	44.6	
More than 20 mins	9	8.0	
Cycling time to sports and leisure facilities			1-5 mins
1-5 mins	83	74.1	
6-20 mins	27	24.1	
More than 20 mins	2	1.8	

Table B2.

Loneliness (n = 112; Mdn = 2.00; Mode = 2)

		Frequency	Percent	Cumulative Percent
Valid	0	24	21.4	21.4
	1	20	17.9	39.3
	2	25	22.3	61.6
	3	18	16.1	77.7
	4	12	10.7	88.4
	5	9	8.0	96.4
	6	4	3.6	100.0
	Total	112	100.0	

Table B3.

Descriptive Statistics Physical Activity (n = 81)

			Statistic	Std. Error
Physical Activity	Mean		2181.7377	195.29398
	95% Confidence Interval for Mean	Lower Bound	1793.0902	
		Upper Bound	2570.3851	
	5% Trimmed Mean		2007.8870	
	Median		1644.7500	
	Variance		3089318.975	
	Std. Deviation		1757.64586	
	Minimum		266.00	
	Maximum		8032.50	
	Range		7766.50	
	Interquartile Range		2101.00	
	Skewness		1.437	.267
	Kurtosis		1.877	.529

Table B4.

Sociodemographic characteristics (n = 112)

	N	%	Mode
Sociodemographic characteristics			
Gender			Female
Female	64	57.1	
Male	48	42.9	
Age			65+
18-24	13	11.6	
25-34	15	13.4	
35-44	8	7.1	
45-64	29	25.9	
65+	47	42	
Household type			Living with a partner
Living alone	23	20.5	
Living with a partner	56	50.0	
Living with a partner and child/children	16	14.3	
Living alone and with child/children	0	.0	
Several people with several budgets	10	8.9	
Other	7	6.3	
Building type			House
Apartment	42	37.5	
Shared apartment	4	3.6	
House	66	58.9	
Length of residence			More than 20 years
Less than a year	5	4.5	
1-5 years	22	19.6	
6-10 years	14	12.5	
11-20 years	16	14.3	
More than 20 years	55	49.1	

Table 2.

Differences in loneliness between urban and rural areas (n = 112)

			Urban or rural area		
			Urban	Rural	Total
Loneliness	0	Count	10	14	24
		% within Urban or rural area	16,4%	27,5%	21,4%
	1	Count	8	12	20
		% within Urban or rural area	13,1%	23,5%	17,9%
	2	Count	17	8	25
		% within Urban or rural area	27,9%	15,7%	22,3%
	3	Count	15	3	18
		% within Urban or rural area	24,6%	5,9%	16,1%
	4	Count	5	7	12
		% within Urban or rural area	8,2%	13,7%	10,7%
	5	Count	3	6	9
		% within Urban or rural area	4,9%	11,8%	8,0%
	6	Count	3	1	4
		% within Urban or rural area	4,9%	2,0%	3,6%
Total		Count	61	51	112
		% within Urban or rural area	100,0%	100,0%	100,0%

Table B5.

Physical Activity in Urban and Rural areas

	Urban or Rural Area	N	Mean	Std. Deviation	Std. Error Mean
Physical Activity	Urban	42	2121,0774	1598,75998	246,69402
	Rural	39	2247,0641	1933,27623	309,57195

Table B6.

Independent Samples Test (1)

		Levene's Test for Equality of Variances	
		F	Sig.
Physical Activity	Equal variances assumed	1,133	,290
	Equal variances not assumed		

(Table continues)

Independent Samples Test (2)

t-test for Equality of Means						
					95% Confidence Interval of the Difference	
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
-,321	79	,749	-125,98672	393,06664	-908,36629	656,39285
-,318	73,948	,751	-125,98672	395,84433	-914,73302	662,75957

9.2 Graphs

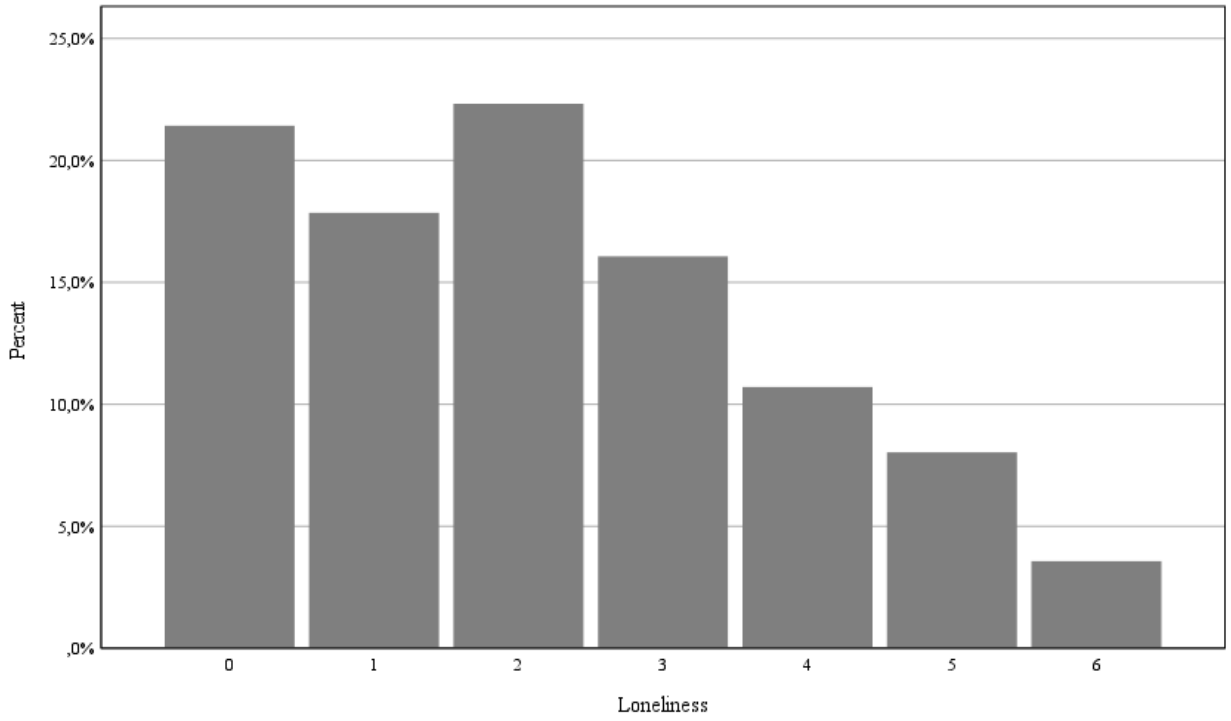

Figure B1. *Distribution of loneliness scores, UCLA-Scale (n = 112)*

Figure B2. Percentages of loneliness scores in urban and rural areas

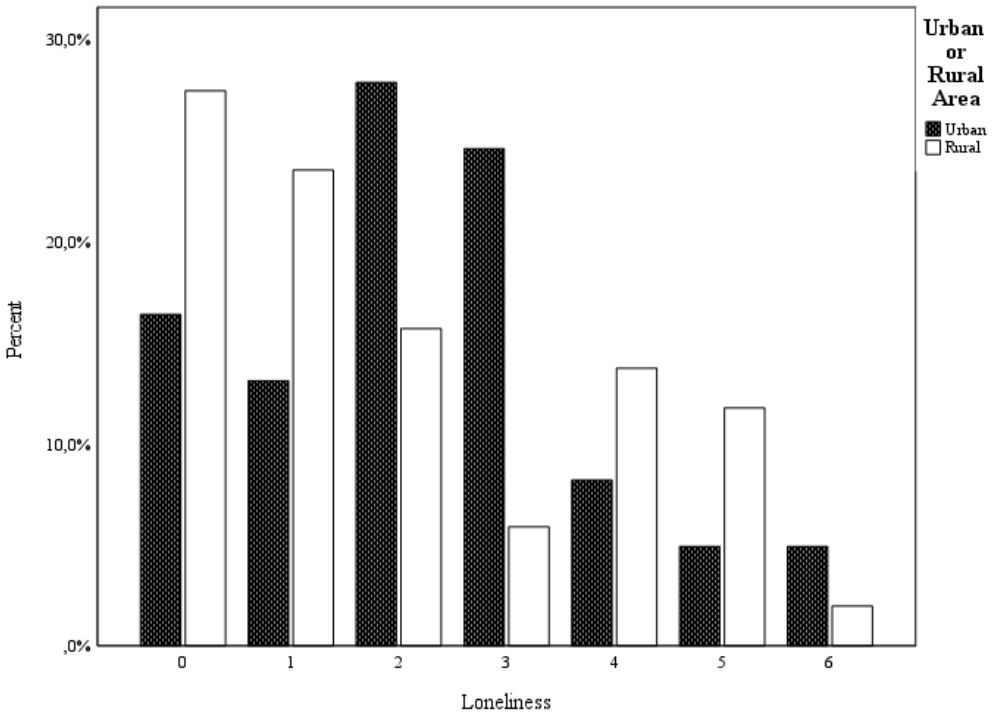

Figure B3. *Median and interquartilrange differences of urban and rural PA*