Exercise behaviour
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Document Version
Publisher's PDF, also known as Version of record

Publication date:
1995

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):

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CHAPTER 4

4. Seasonal variation in leisure time physical activity

Summary In this chapter seasonal variation in leisure time physical activity for exercise is studied and quantified with regard to several popular exercise activities and taking the respondents' gender, occupational status and age into consideration. The analysis concerns data collected between January 1989 and March 1992. Data from 7,202 male and 9,284 female respondents is used in the analysis, cosinor analysis using GLIM is applied. Considerable seasonal variation is found affecting both outdoor and indoor activities. During the peak phase in July, 32% of the respondents reported exercising for at least 20 minutes 3 or more times during the previous week, in the winter period this decreased to 23%. Older respondents exercise more later in the year and also showed seasonal variation to a larger extent than younger respondents. The difference between the age groups is particularly pronounced for the respondents reporting to exercise according to the demanding definition of exercise.

Introduction

Although seasonal variation is one of the important characteristics of exercise and sports activities, to date only a few studies have studied seasonal variation in physical activity (Magnus, Matroos, & Stackee, 1979; Dannenberg, Keller, et al, 1989). In this chapter data on leisure time physical activity for exercise collected on a monthly basis between January 1989 and March 1992 will be studied from the perspective of seasonal variation.

A number of reasons can be put forward for studying seasonal variation in exercise activity. First, of course, seasonal variation in exercise activity is of interest for the study of physical activity behaviour itself, as the results of a study of physical activity patterns might be dependent on the period of the year a study is carried out. Second, there is evidence which suggests that the lower risk for cardiovascular disease found among physically active individuals as opposed to sedentary individuals is not found among those who temporarily interrupt their exercise behaviour. Magnus, Matroos and Strackee (1979) found a negative association between acute coronary events and exercising for at least eight months per year. No such relationship was found among those who exercised for a shorter period. Magnus, Matroos and Strackee suggest that this might be caused by starting exercising after a sedentary period, given the fact that, although in itself exercise behaviour improves coronary health, considerably increasing physical activity might carry certain coronary risks. The data presented in this chapter on exercise behaviour will allow for comparisons with data presented in the literature on cardiovascular disease (Anderson, & LeRiche, 1970; Douglas, Allen, & Rawles, 1991; Tsementzis, Kennet, et al, 1991), to see to what extent there might a relationship between seasonal variation in exercise behaviour and seasonal variation in cardiovascular disease. Third, within the context of psychiatric health there is evidence that exercise activity continued throughout the year has a protective effect in relation to seasonal mood changes (Suter, Marti, et al, 1991). This leads to the question, to what extent is a relatively low level of physical activity during the winter period a causal factor in seasonal mood changes? Fourth, seasonal variation might be important from the perspective of the study of the sociological and psychological dimensions of exercise behaviour (RUHBC, 1989). Exercise is a time consuming behaviour and has to compete for time with other work, household and leisure time obligations. Exercise can only become a stable habit if embedded in the daily lifestyle. It seems logical to think that stopping
exercising for ‘the winter period’ might be a powerful precursor of stopping exercising for good and one might ask the question to what extent certain social groups are more affected by this phenomenon than others.

As there are few theories and empirical studies in relation to seasonal variation in physical activity for exercise the above rationales for this chapter are necessarily tentative and incomplete. The aim of this chapter is therefore modest and concentrates on the description and quantification of seasonality in leisure time physical activity for exercise asking the question about which socio-demographic groups and which types of physical activity are most affected by seasonal variation.

**Data and methods**

The data analyzed were collected between January 1989 and March 1992. As no data were collected in April 1991 this month is ignored in the analysis. In total the analysis concerns 7,202 male and 9,284 female respondents, 77 respondents who did not answer the physical activity question were excluded from the analysis.

Classifying the respondents according to the less demanding definition, ie. exercising at least once in the previous week for at least 20 minutes, resulted in 4,262 males (59.2%) being classified as physically active while 2,940 males (40.8%) were classified as non-active, for females the figures were 4,752 (51.2%) and 4,532 (48.8%) respectively. The demanding categorization, which dichotomized the respondents into those who reported exercising three times or more during the past week and those who reported exercising less often, resulted for males in 2,317 (32.2%) and 4,885 (67.8%), and for females 2,252 (24.3%) and 7,032 (75.7%), exercisers and non-exercisers respectively.
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A number of methods can be applied to study seasonality in time trend data. These methods are based on a number of different 'paradigms' each based on different assumptions and with different theoretical and methodological implications (Kenny, & Durbin, 1982). In this chapter cosinor analysis was used: in a regression analysis a sinoid seasonal term was fitted to the data (Tong, 1976; Nelson, Tong, et al, 1979). This method was preferred above other techniques because of 1) its simplicity and the easy interpretability of the estimated parameters, 2) it takes into consideration that the data consists of samples and is not at the unit level and 3) is consistent with the theoretical notion that an underlying seasonal phenomenon of a continuous nature 'causes' population physical activity levels and that in the analysis this 'process' is modeled to the data. The following cosinor model was fitted to the data using GLIM.

\[ Y = \mu + \alpha \cdot \text{Time} + \beta \cdot \sin(\text{Period}) + \tau \cdot \cos(\text{Period}) \]

Whereby:

- \( Y \) is the proportion of exercisers in a particular month.
- \( \mu \) is the intercept.
- \( \alpha \cdot \text{Time} \) is a linear term to measure long term trends, \( \text{Time} \) is the month number: January 1989 = 1 .. March 1992 = 39 (April 1991 (28) missing).
- Period is the month of the year in degrees: January = 15 .. December = 345 degrees.

1) From the analysis the phase, the exact horizontal position of the sinoid, and the standard error of the phase can be derived.

\[ \text{Phase} = \arctan(\frac{\tau}{\beta}) \]

2) From the analysis the amplitude, the maximum difference between the trend and the sinoid, and the standard error of the amplitude can be derived. Amplitude\(^2\) = \( \beta^2 + \tau^2 \)

A regression analysis weighted for the number of cases per month is used to estimate the parameters\(^7\). In the results section the

\(^7\) One should take note of the peculiarities of this way of analysing data. At the centre of the analysis are data which are summarized over months. For example, the number of exercisers in a month, expressed relative to the number of respondents in that month, are explained by the number of months elapsed since the first month analyzed (the 'trend'), the number of months elapsed in the year currently analyzed (the 'seasonality'), and the month currently analyzed (a
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following statistics will be presented: 1) the phase or month in which the highest proportion of respondents report being physically active for exercise. The phase is measured in degrees, the whole year being 360 degrees. According to the model, the lowest level can be observed six months, or 180 degrees, later or earlier as the highest level; 2) The amplitude to measure the extent of seasonality. 3) As counted data is used, Pearson Chi-square will be presented to see if the model fits the data 8. 4) Data on longer term trends will be presented as a matter of course. In general the findings of the analysis presented in this chapter with regard to longer term trends were similar to the conclusions of a previous paper (Uitenbroek, & McQueen, 1992a): that the proportion of the population engaging in physical activity for exercise is increasing overtime. Of all estimates the standard errors will be presented. The parameter values and the standard errors will be used to calculate relevant t-values. T-values larger than 2.00 will be declared statistically significant, given the high number of cases used in the analysis this equals a p-value of under 0.05.

'special' month or not). However, this is not an aggregated data analysis. In Glim the variance of the data for the months is taken into consideration, contrary to aggregate data analysis. Glim calculates the within month variance in the case of proportions while the variance is transferred to the program as a separate scale parameter in the case of continuous dependent variables.

8 How to appropriately model, and what the role of goodness-of-fit statistics should be, is the topic of much discussion among methodologists. From a statistical perspective only models which fit the data satisfactorily, the p-value of the goodness-of-fit statistic is above a critical value, provide valid statistics. However, a problem arises if one has more than one model which fits the same data satisfactorily and a 'subjective' judgment must be made to decide between models. In such a situation preference is given to models which make most sense theoretically, which 'fit' the real world and the qualitative expectations we have of this world. But what should be done in the case of a model which fits theoretically, but which does not fit statistically, as opposed to a model which fits statistically, but does not fit theoretically? In this paper the position is taken that we fit our theoretical model, which exists a-priori and before any statistical testing, to the data. If the fit is not satisfactory the residuals of the model are studied to see if there are any outliers or other phenomena which require ad-hoc explanation. If not, the model is passed even if the statistical fit is not perfect. This position is also taken given that the analysis presented here is based on a high number of cases and a high number of cells to explain. When large samples are involved test statistics become very critical and should one only allow well fitting models one runs the risk of having to develop many additional, and often nonsensical, theories.
Results

In figure 4.1 the proportions of respondents who reported exercising at least once during the previous week and of respondents who reported exercising three or more times are shown for each month of observation. The fluctuating lines denote the expected values estimated by way of the cosinor analysis. Two of the basic concepts of the analysis, phase and amplitude, are displayed in the figure. The statistics for the two sinoids displayed in figure 4.1 are given on the first two lines of table 4.1. As can be seen in table 4.1, the proportion of respondents reporting exercising according to the less demanding definition is highest around mid July. For those reporting to have exercised at least three times per week the peak is about a week earlier. At this period the proportion of the population who exercise at the lower frequency is approximately 4.6% more than the trend for the full year, during the peak period approximately 4.2% more respondents compared with the trend report exercising at the
higher frequency. The amplitude divided by its standard error gives the t-values, 9.2 and 7.0 respectively, this shows that the seasonality observed is highly statistically significant. In the last two columns the average proportion of respondents reporting exercising over the full 38 months and the Pearson Chi-square are shown. For reporting exercising once or more often the Chi-square of 30 over 34 degrees of freedom, giving a p-value of over .25, shows that the model fits the data very well. For reporting exercising three times or more often the Chi-square of 55 gives a model fit which is less satisfactory, taking into consideration that the critical value of Chi-square for \( p=0.05 \) is 49 by 34 degrees of freedom, a value below which the model could have been declared satisfactory. Inspection of figure 4.1 shows that the high Chi-square is probably caused by fluctuation in the first half of 1989 and does not seem to have been caused by particular periods being systematically different from the model expectations.

Table 4.1 further shows the statistics for the sinoid fitted separately for a number of commonly reported physical activities. With the exception of jogging/running and keep-fit exercise seasonality is common to all of these activities. The extent of the seasonality seems generally small, around one percent,
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however, one has to take into consideration that the data concerns percentages which take all respondents into consideration. For single activities the results can be quite dramatic. For example, not taking longer term trends into consideration, approximately 1.0% of the respondents report playing golf three times or more often during the past week on average. With a seasonal amplitude of 0.7% this results in approximately 0.3% percent of the respondents reporting playing golf three times or more often during the past week in the winter period against 1.7% in August, more than five times as many. The model fit seems in general to be satisfactory staying below or very near the critical value for Chi-square. The exception is swimming three or more times in the previous week which yields a Chi-square of 73.3. Inspection of the data showed that, again, this was caused by a strong fluctuation in the first half of 1989.

Table 4.2 Seasonal variation and trend in physical activity for exercise by gender, age and occupational status. Based on monthly data, 1989-1992.

<table>
<thead>
<tr>
<th>Peak Phase</th>
<th>Deg (S.E.)</th>
<th>Ampl. (S.E.)</th>
<th>Trend (S.E.)</th>
<th>Mean (S.E.)</th>
<th>Fit (d.f.)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercising once or more often last week</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>late July</td>
<td>200 (0.2)</td>
<td>4.5% (0.8)</td>
<td>0.14% (0.05)</td>
<td>58.9% (0.6)</td>
<td>35.3 (34)</td>
<td>7,202</td>
</tr>
<tr>
<td>mid July</td>
<td>190 (0.1)</td>
<td>4.8% (0.6)</td>
<td>0.17% (0.04)</td>
<td>51.0% (0.5)</td>
<td>21.0 (34)</td>
<td>9,284</td>
</tr>
<tr>
<td>Professionals/Intermediate</td>
<td>194 (0.2)</td>
<td>4.7% (0.8)</td>
<td>0.08% (0.05)</td>
<td>64.9% (0.6)</td>
<td>23.5 (34)</td>
<td>5,456</td>
</tr>
<tr>
<td>Skilled non-manual</td>
<td>189 (0.2)</td>
<td>4.5% (1.0)</td>
<td>0.17% (0.06)</td>
<td>55.9% (0.8)</td>
<td>28.6 (34)</td>
<td>3,972</td>
</tr>
<tr>
<td>Skilled manual</td>
<td>180 (0.4)</td>
<td>4.1% (1.5)</td>
<td>0.28% (0.09)</td>
<td>47.2% (0.9)</td>
<td>41.6 (34)</td>
<td>2,924</td>
</tr>
<tr>
<td>Semi/Unskilled</td>
<td>191 (0.3)</td>
<td>6.8% (1.8)</td>
<td>0.23% (0.11)</td>
<td>40.1% (1.1)</td>
<td>47.8 (34)</td>
<td>2,149</td>
</tr>
<tr>
<td>Age 18 to 25</td>
<td>late June</td>
<td>171 (0.2)</td>
<td>5.0% (1.1)</td>
<td>0.16% (0.07)</td>
<td>68.0% (0.9)</td>
<td>24.5 (34)</td>
</tr>
<tr>
<td>Age 26 to 35</td>
<td>late June</td>
<td>175 (0.3)</td>
<td>4.1% (1.0)</td>
<td>0.11% (0.06)</td>
<td>59.7% (0.7)</td>
<td>33.9 (34)</td>
</tr>
<tr>
<td>Age 36 to 45</td>
<td>mid July</td>
<td>199 (0.3)</td>
<td>4.9% (1.3)</td>
<td>0.20% (0.08)</td>
<td>52.9% (0.8)</td>
<td>42.9 (34)</td>
</tr>
<tr>
<td>Age 46 to 60</td>
<td>early Aug</td>
<td>213 (0.2)</td>
<td>6.0% (1.0)</td>
<td>0.20% (0.06)</td>
<td>42.7% (0.7)</td>
<td>32.3 (34)</td>
</tr>
<tr>
<td>Exercising three times or more often last week</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>late July</td>
<td>198 (0.2)</td>
<td>3.8% (0.6)</td>
<td>0.17% (0.06)</td>
<td>32.2% (0.6)</td>
<td>45.7 (34)</td>
<td>7,202</td>
</tr>
<tr>
<td>early July</td>
<td>180 (0.2)</td>
<td>4.8% (0.7)</td>
<td>0.16% (0.04)</td>
<td>24.1% (0.4)</td>
<td>39.5 (34)</td>
<td>9,284</td>
</tr>
<tr>
<td>Professionals/Intermediate</td>
<td>179 (0.2)</td>
<td>5.8% (1.0)</td>
<td>0.11% (0.06)</td>
<td>31.5% (0.6)</td>
<td>36.9 (34)</td>
<td>5,456</td>
</tr>
<tr>
<td>Skilled non-manual</td>
<td>186 (0.3)</td>
<td>4.0% (1.1)</td>
<td>0.14% (0.07)</td>
<td>26.1% (0.7)</td>
<td>44.2 (34)</td>
<td>3,972</td>
</tr>
<tr>
<td>Skilled manual</td>
<td>168 (0.4)</td>
<td>3.0% (1.3)</td>
<td>0.20% (0.08)</td>
<td>26.2% (0.8)</td>
<td>41.2 (34)</td>
<td>2,924</td>
</tr>
<tr>
<td>Semi/Unskilled</td>
<td>late July</td>
<td>206 (0.4)</td>
<td>4.1% (1.5)</td>
<td>0.18% (0.09)</td>
<td>20.8% (0.9)</td>
<td>50.7 (34)</td>
</tr>
<tr>
<td>Age 18 to 25</td>
<td>early June</td>
<td>156 (0.7)</td>
<td>2.0% (1.4)</td>
<td>0.22% (0.08)</td>
<td>33.4% (0.9)</td>
<td>34.1 (34)</td>
</tr>
<tr>
<td>Age 26 to 35</td>
<td>early July</td>
<td>183 (0.3)</td>
<td>3.8% (1.3)</td>
<td>0.10% (0.08)</td>
<td>28.0% (0.6)</td>
<td>64.3 (34)</td>
</tr>
<tr>
<td>Age 36 to 45</td>
<td>early July</td>
<td>183 (0.3)</td>
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<td>0.19% (0.05)</td>
<td>25.8% (0.6)</td>
<td>31.7 (34)</td>
</tr>
</tbody>
</table>

Finally, table 4.2 shows the seasonality for all activities by the respondents gender, age and occupational status. As can be seen the peak phase for seasonality in physical activity for exercise falls somewhat later in the year for males when compared to females, this difference is statistically significant according to both definitions of physical activity (t=44.7 and
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t=28.3 respectively). Further it seems that the amplitude of the seasonality is somewhat more pronounced for females than for males, however, this difference is not statistically significant (t=0.5 and t=1.1). The analysis by occupational category does not show systematic patterns, also, testing the hypothesis of a similar population phase for all occupational categories against the hypothesis of separate phases per group does not yield statistically significant results (F=0.65; p>0.25 and F=0.49, p>0.25 less demanding and demanding respectively). Further, the differences in amplitude between the occupational categories are only statistically significant for the group of respondents who reported to have exercised at least three times during the previous week (F=3.76, p<0.05). The analysis by age shows a number of notable features. First, there is a relation between the age of the respondents and the phase of the seasonality in their exercise behaviour, with older respondents having the summer peak, and by implication also the winter trough, later in the year than younger respondents, this effect is statistically significant for the respondents who reported exercising three or more times during the previous week (F=4.36, p<0.05). Further, the amplitude of the seasonality increases with age, again, this is particularly clear in relation to the respondents who report more frequent exercising (F=4.39, p<0.05). Finally, the fit of the models seems to be in general satisfactory with only two Chi-squares being larger than the critical value of 49 over 34 degrees of freedom.

Discussion

In this chapter seasonality in leisure time physical activity for exercise was studied and quantified according to two definitions of physical activity: one contrasting respondents who reported having exercised at least once for 20 minutes or more during the previous week with respondents who reported having exercised less often; the other definition contrasting respondents who reported having exercised at least three times for 20 minutes
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with respondents who reported having exercised less than three times in the previous week. Considerable seasonality was found with a peak in early and mid July which resulted in the proportion of the population classified as physically active fluctuating between 50.1 and 59.4% and between 23.4 and 31.8% according to the two definitions respectively. Considering other lifestyle and health behaviours in which no seasonality or only limited seasonality can be observed (Uitenbroek, 1993b) the extent of seasonality in physical activity for exercise is quite exceptional. Given the aggregated nature of this and other data it is difficult to generalize the findings in the light of the methodological, health and socio-psychological dimensions mentioned in the introduction. Further, it needs to be taken into consideration that the data considers two urban areas, both at a high latitude. Scotland has a latitude similar to Southern Alaska; thus there is a large difference in the number of hours of daylight between summer and winter. However, because of Scotlands coastal climate extreme seasonal temperature differences are uncommon.

From a methodological perspective, seasonality is an important factor to consider in studies of physical activity patterns and consequently it is important that such studies consider full calendar years or be explicitly limited to particular periods of the year. It is of note that seasonality was very widespread among popular exercise activities and also affected indoor activities such as aerobics and, in Scotland primarily indoors, swimming. The question of whether there is a relationship between seasonal changes in exercise behaviour and seasonal changes in coronary mortality was asked in the introduction. Magnus, Matroos, and Strackee (1979) postulated that when exercise behaviour increases the risk of coronary mortality also increases. However, comparing the data presented in this chapter with data presented in the literature shows that the relationship is not a simple one given the fact that if reported exercise activity increases in the spring, coronary morbidity and mor-
statistical description


With regard to changes in psychiatric mood, physical activity seems to cycle in a similar phase as seasonal mood fluctuations (Jacobsen, Wehr, et al, 1987; Eastwood, & Peter, 1988; Wehr, & Rosenthal, 1989; Nelson, Badura, et al, 1990). The role of low levels of physical activity in depressed winter moods and the related changes in weight warrants further research. The above mentioned socio-psychological factors in exercise up-take the data seems to contradict the hypothesis that stopping exercising for the winter period is one of the causes of stopping exercising for good. In this case one would expect seasonality to decrease with age as seasonal exercisers permanently give up exercising, however, the data shows the opposite pattern. It seems therefore that seasonal variation in physical activity for exercise can be successfully incorporated into peoples’ yearly lifestyles.

The analysis of seasonality in exercise behaviour by socio-demographic group shows the following. Between the two sexes the differences are small and not statistically significant although seasonal effects are stronger for females compared with males. With regard to the various occupational categories the differences are again small and the seasonal effects are most pronounced among the lower occupational categories if one considers exercising once or more often per week, however, seasonality is more pronounced among the higher occupational categories if one considers exercising three times or more often per week. Among those who report exercising three times or more often per week for twenty minutes or more, seasonality increases quite strongly with age. Therefore, the lower reporting of vigorous exercising in older age groups compared with younger age groups is partly caused by exercise behaviour becoming more seasonal with
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increasing age, with the difference between the age groups being quite small in the summer.

Lastly, the question that must be asked is, what causes seasonal variation in exercise behaviour to be so widespread among physical activities and social groups? There has been considerable research into the influence of environmental fluctuations, particularly changes in the number of hours of day light, on the human biology and ‘winter moods’ might explain part of the variation found (Anderson, & LeRiche, 1970; Magnus, Matroos, & Strackee, 1979; Eastwood, & Peter, 1988; Tsementzis, Kennet, et al, 1991). Second, phenomena such as holidays, -people being more active in the summer holidays- might provide another possible explanation. A last explanation that comes to mind is that Scotlands dark winter afternoons and evenings might make people, particularly females and the older aged, unwilling to leave the safety of their homes to engage in exercise.