Physical activity during leisure time and quality of life in a Spanish cohort: SUN (Seguimiento Universidad de Navarra) Project

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ABSTRACT

Background Leisure-time physical activity (LTPA) has been associated with better mental and physical health particularly in cross-sectional studies.

Purpose To longitudinally assess the association between LTPA, changes in LTPA and health-related quality of life (HRQL).

Methods Cross-sectional and prospective analysis of the Seguimiento Universidad de Navarra Project, a dynamic cohort study. Information is gathered through mailed questionnaires biannually since 1999. A validated LTPA questionnaire was used to assess LTPA level at baseline. Changes in LTPA were ascertained at 2 and 4 years of follow-up. HRQL was assessed at 4 and 8 years of follow-up with a validated Spanish version of the SF-36 Health Survey. Multivariate regression coefficients, means and their 95% CIs for each of the eight domains of the SF-36 according to quintiles of baseline LTPA and changes in LTPA over time were calculated using generalised linear models.

Results At 4 years of follow-up, mean scores for upper quintiles of LTPA (second to highest quintile) of physical functioning, general health, vitality, social functioning and mental health were significantly higher than the mean score obtained for participants with the lowest level of LTPA (first quintile). In general, and independent of previous scores in SF-36 survey, the maintenance or the increase in LTPA levels during follow-up was associated with better scores in HRQL after 8 years of follow-up, especially for mental domains.

Conclusion These findings provide support for an association between LTPA, long-term changes in LTPA and several aspects of HRQL (especially in relation to mental domains) extending previous cross-sectional findings.

BACKGROUND

Physical inactivity is estimated to contribute to at least 2 million deaths per year globally and is recognised as one of the most important public health problems in the 21st century. Although the effects of diet and physical activity (PA) on health often interact, particularly in relation to obesity, there are additional health benefits to be gained from regular PA that are independent of nutrition and diet. Indeed, PA has been independently associated with reduced risk of developing major chronic disease (both physical and mental) and reduced mortality. Cross-sectional studies in samples of general population and in patients have found that PA levels are positively associated with physical functioning, vitality and mental health. In many of these studies, physically active individuals reported fewer unhealthy days (physical or mental) although this finding is not universal. This research also suggests that PA is associated with greater well-being, successful ageing and improved global quality of life although some studies have found no association. These equivocal results may be due to differences in research design and also due to the small sample size in some studies.

To our knowledge, longitudinal studies on this issue were mostly short-term interventions conducted mainly in a clinical setting. Moreover, the available longitudinal studies carried out in healthy population, regardless of them being observational or experimental in design, showed, in general, insufficient quality to examine a causal relationship between leisure-time PA (LTPA) and health-related quality of life (HRQL). In order to establish a true cause–effect association, a longitudinal design is needed such that changes over time in LTPA could be related to HRQL.

So, the aim of the present study was to assess the association between LTPA, changes in LTPA over time and HRQL in a prospective cohort study, the SUN Project.

METHODS

The SUN Project is a multipurpose dynamic (recruitment is permanently open) cohort study based on university graduates from Spain. It was started in 1999 and is permanently on-going. The methods of this cohort have been described elsewhere. Information is gathered through mailed questionnaires sent by mail or responded through internet every 2 years. Up to March 2010, 12 576 participants had responded to the baseline (Q_0) and to the 4-year follow-up (Q_4) questionnaires and 5029 participants had responded to the Q_0, Q_4 and to the 8-year follow-up (Q_8) questionnaires. These figures cannot be interpreted whatsoever as retention rates because the lower number in the 8-year assessment is explained by late entries in the cohort. As the recruitment is permanently open, with approximately 2000 new participants each year, only those who had entered the cohort before 2002 could be followed up for 8 years. Actually, the overall retention rate is 92%. From those participants who were assessed after 4-year (12 576) or 8-year follow-up (5029), those who reported rheumatoid arthritis at baseline and those with missing values in the variables of interest were excluded. Finally, 11 938 participants were...
included in the analyses up to 4 years and 4206 participants for the analyses up to 8 years of follow-up (figure 1).

The study was approved by the Institutional Review Board of the University of Navarra. Voluntary completion of the first questionnaire after having read information concerning the study was considered to imply informed consent.

**Exposure assessment**

The baseline questionnaire (Q_0) included an LTPA questionnaire collecting information about 17 activities. To quantify the volume of activity during leisure time, an activity metabolic equivalent (MET) index was computed by assigning a multiple of resting metabolic rate (MET score) to each activity, and the time spent in each of the activities was multiplied by the MET score specific to each activity, and then summed over all activities to obtain a value of overall weekly MET-hours. Finally, the continuous variable was categorised into quintiles.

LTPA estimated using the questionnaire was previously validated by our group using a triaxial accelerometer as the gold standard. LTPA (estimated as MET-hours per week) derived from the questionnaire moderately correlated with kilocalories per day assessed through the accelerometer (Spearman’s r=0.507, 95% CI=0.232 to 0.707, p<0.001).

Moreover, change in LTPA level from baseline up to 4 years of follow-up was ascertained. Q_2 and Q_4 included a question enquiring about changes in LTPA (increase, decrease or maintenance of LTPA) since baseline. Thus, the joint exposure to both baseline level of LTPA (tertiles) and changes during follow-up (increase or maintenance vs decrease in LTPA) was also analysed.

**Outcome assessment**

HRQL was assessed in Q_4 and Q_8 with a validated Spanish version of the SF-36 Health Survey. This questionnaire contains 36 items that measure eight multi-item parameters of health status: physical functioning, role limitations due to physical health problems (role physical), bodily pain, general health perceptions, vitality, social functioning, role limitations due to emotional problems (role emotional) and mental health. The first four domains deal with physical aspects and the next four reflect psychological features. For each parameter, scores are coded, summed and transformed to a scale from 0 (the worst possible condition) to 100 (the best possible condition).

**Other covariate assessment**

Q_0 also included information on different sociodemographic (sex and age), anthropometric (weight and height), medical (history of cardiovascular disease, cancer or diabetes) and lifestyle-related (smoking status) characteristics of the participants.

**Statistical analysis**

The regression coefficients and their 95% CIs for each of the eight domains according to quintiles of baseline LTPA were calculated using generalised linear models. Age, sex, baseline body mass index, history of chronic diseases and smoking status were considered as possible confounders. Moreover, for the analysis up to 8 years of follow-up, SF-36 scores in Q_4 and change in LTPA from baseline up to 4 years of follow-up were also included as covariates. Test of linear trend across successive LTPA quintiles was calculated by assigning the medians to each quintile and treating the level of LTPA as a continuous.

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**Figure 1** Flowchart of participants: the SUN Project.
variable. Moreover, statistical differences in multivariate adjusted mean scores between quintiles of LTPA were determined by analysis of covariance.

Two-tailed p values <0.05 corrected for multiple comparisons using a post hoc procedure (Benjamini–Hochberg correction) were calculated.

The SPSS software package for Windows version 17.0 (SPSS, Chicago, Illinois, USA) was used for statistical analyses.

Differences in the eight parameters of the SF-36 according to the level of LTPA can be assessed along two concepts: clinical and statistical differences. Clinically significant differences are defined as a 5-point difference in the 0–100 scale, whereas statistically significant differences were defined as two-tailed p<0.05.

**RESULTS**

The main characteristics of the participants according to quintiles of LTPA are presented in table 1. The percentage of men and never smokers were higher among those with the highest level of activity. No statistically significant differences between categories of LTPA were reported for the prevalence of several diseases at baseline.

Regression coefficients and their 95% CIs for the association between LTPA and HRQOL are shown in table 2. After 4 years of follow-up, higher levels of LTPA at baseline were associated with higher scores in all the SF-36 domains (with significant dose–response relationships). The results for three of the mental domains (vitality, mental health and role emotional) and for physical functioning were especially relevant. Moreover, not only a statistically significant but also a clinically relevant difference was obtained for vitality in participants belonging to the highest quintile of LTPA as compared with subjects in the first quintile (b=5.25; 95% CI=4.32 to 6.13). When the analyses were repeated after 8 years of follow-up and adjusted for the scores obtained in Q_4 and for changes in LTPA from baseline, only the subjects in the highest quintile of LTPA showed significantly higher scores for physical and social functioning, general health and vitality.

The adjusted means for the eight domains after the 4-year follow-up (Q_4) according to quintiles of baseline LTPA with

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Main characteristics of the SUN participants according to quintiles of physical activity during leisure time (at baseline)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quintile</td>
<td>Median (METs-h/week)</td>
</tr>
<tr>
<td>Lowest (n=2405)</td>
<td>4.8</td>
</tr>
<tr>
<td>Second (n=2370)</td>
<td>11.2</td>
</tr>
<tr>
<td>Third (n=2388)</td>
<td>19.1</td>
</tr>
<tr>
<td>Fourth (n=2388)</td>
<td>29.1</td>
</tr>
<tr>
<td>Highest (n=2387)</td>
<td>49.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Regression coefficients (95% CI) by quintiles of physical activity during leisure time (at baseline) on the SF-36 health status questionnaire (after 4 and 8 years of follow-up) (SUN study participants)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Follow-up (years)</td>
<td>Lowest quintile</td>
</tr>
<tr>
<td>Median (METs-h/week)</td>
<td>4.8</td>
</tr>
<tr>
<td>Physical functioning</td>
<td>4</td>
</tr>
<tr>
<td>8*</td>
<td>0 (ref.)</td>
</tr>
<tr>
<td>Role physical</td>
<td>4</td>
</tr>
<tr>
<td>8*</td>
<td>0 (ref.)</td>
</tr>
<tr>
<td>Bodily pain</td>
<td>4</td>
</tr>
<tr>
<td>8*</td>
<td>0 (ref.)</td>
</tr>
<tr>
<td>General health</td>
<td>4</td>
</tr>
<tr>
<td>8*</td>
<td>0 (ref.)</td>
</tr>
<tr>
<td>Vitality</td>
<td>4</td>
</tr>
<tr>
<td>8*</td>
<td>0 (ref.)</td>
</tr>
<tr>
<td>Social functioning</td>
<td>4</td>
</tr>
<tr>
<td>8*</td>
<td>0 (ref.)</td>
</tr>
<tr>
<td>Role emotional</td>
<td>4</td>
</tr>
<tr>
<td>8*</td>
<td>0 (ref.)</td>
</tr>
<tr>
<td>Mental health</td>
<td>4</td>
</tr>
<tr>
<td>8*</td>
<td>0 (ref.)</td>
</tr>
</tbody>
</table>

Adjusted for age, sex, baseline body mass index, history of chronic diseases (cancer, cardiovascular disease and diabetes) and smoking status.

*Additionally adjusted for change in physical activity during 4 years of follow-up and SF-36 score in Q_4 (n=4206).

the Benjamini–Hochberg post hoc correction for the multiple between-pairs comparisons are presented in table 3. Overall, the SF-36 scores for seven of the eight domains (exception: role physical) were statistically different according to quintiles of LTPA. Mean scores for the upper categories (second to fifth quintile) of LTPA for physical functioning, general health, vitality, social functioning and mental health were higher than for participants with the lowest baseline LTPA level (first quintile). Moreover, subjects belonging to the fifth quintile of LTPA showed a significantly higher score for role emotional domain compared with lowest level of activity (mean of role emotional score for the lowest quintile: 85.0 (95% CI=81.9 to 88.1) vs mean for the highest quintile: 88.3 (85.3 to 92.4)).

Table 4 shows the results obtained after considering both baseline exposure to LTPA (in tertiles) and changes during follow-up. In general, and independent of previous score in SF-36 survey (collected in Q_4), the maintenance or the increase in LTPA levels during follow-up was associated with better scores in HRQOL after 8 years of follow-up, especially for mental domains.

### DISCUSSION
Results of the present study suggest direct and significant associations between LTPA and HRQL both in the cross-sectional and the longitudinal analyses. After 4 years of follow-up, higher levels of LTPA at baseline were associated with higher scores in all the SF-36 domains with a significant dose–response relationship. When the analyses were repeated after 8 years and adjusted for the scores after 4-year follow-up and for changes in LTPA, subjects in the highest quartile showed significantly higher scores for physical and social functioning, general health and vitality. Longitudinal data also showed that independent of previous HRQL scores, the maintenance or increase in LTPA levels during the follow-up was associated with better SF-36 scores in quality of life after 8 years for all mental domains.

Physical inactivity is widespread and is a major contributor to physical chronic disease, disability and premature mortality. Similarly, considerable knowledge has been accumulated in recent decades concerning the significance of LTPA in the treatment of diseases such as mental diseases and their associated symptoms such as mood, depression, anxiety, stress

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**Table 3** Multivariate adjusted mean scores (95% CI) by quintiles of physical activity during leisure time (at baseline) on the SF-36 health status questionnaire (after 4 years of follow-up)

<table>
<thead>
<tr>
<th>SF-36 scores after 4 years of follow-up</th>
<th>Lowest quintile</th>
<th>Second quintile</th>
<th>Third quintile</th>
<th>Fourth quintile</th>
<th>Highest quintile</th>
<th>ANCOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical functioning</td>
<td>88.7 (87.7 to 89.7)†</td>
<td>90.3 (89.3 to 91.2)**</td>
<td>90.6 (89.6 to 91.6)**</td>
<td>91.0 (90.1 to 92.0)**</td>
<td>91.9 (90.9 to 92.9)**</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Role physical</td>
<td>85.2 (84.2 to 88.1)†</td>
<td>86.6 (83.7 to 89.4)</td>
<td>85.9 (83.1 to 88.8)</td>
<td>86.1 (83.3 to 88.9)</td>
<td>87.4 (84.5 to 90.2)</td>
<td>0.083</td>
</tr>
<tr>
<td>Bodily pain</td>
<td>74.3 (72.1 to 76.5)†</td>
<td>76.3 (73.2 to 77.6)*</td>
<td>75.9 (73.7 to 78.1)*</td>
<td>75.4 (73.2 to 77.6)</td>
<td>76.7 (74.5 to 78.9)*</td>
<td>0.001</td>
</tr>
<tr>
<td>General health</td>
<td>62.1 (60.4 to 63.9)*</td>
<td>63.4 (62.6 to 66.0)**</td>
<td>64.3 (62.5 to 66.0)**</td>
<td>64.7 (63.0 to 66.4)**</td>
<td>66.1 (64.4 to 67.9)**</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Vitality</td>
<td>61.2 (59.4 to 62.9)*</td>
<td>63.7 (61.9 to 65.4)**</td>
<td>64.3 (62.6 to 66.1)**</td>
<td>65.1 (64.3 to 66.8)**</td>
<td>66.4 (64.7 to 68.1)**</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Social functioning</td>
<td>88.8 (87.2 to 90.4)†</td>
<td>90.1 (88.5 to 91.6)*</td>
<td>90.7 (89.1 to 92.2)*</td>
<td>90.7 (89.1 to 92.2)*</td>
<td>91.0 (89.4 to 92.5)*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Role emotional</td>
<td>85.0 (81.9 to 88.2)*</td>
<td>86.1 (83.0 to 89.2)†</td>
<td>87.3 (84.2 to 90.4)</td>
<td>87.4 (84.3 to 90.5)</td>
<td>88.9 (85.3 to 91.4)*</td>
<td>0.001</td>
</tr>
<tr>
<td>Mental health</td>
<td>74.5 (72.9 to 76.0)†</td>
<td>76.0 (74.4 to 77.5)**</td>
<td>76.8 (75.3 to 78.3)**</td>
<td>76.7 (75.2 to 78.2)**</td>
<td>77.7 (76.2 to 79.3)**</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

SUN study participants (N=11 938). Adjusted for age, sex, baseline body mass index, history of chronic diseases (cancer, cardiovascular disease and diabetes) and smoking status.

*Statistically significantly higher (p<0.05) than lowest quintile (Benjamini–Hochberg post-test correction).
†Statistically significantly lower (p<0.05) than highest quintile (Benjamini–Hochberg post-test correction).
‡Statistically significantly higher (p<0.05) than second quintile (Benjamini–Hochberg post-test correction).

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**Table 4** Multivariate adjusted mean scores (95% CI) by the joint exposure to both baseline physical activity (tertiles) and its change during follow-up on the SF-36 health status questionnaire (after 8 years of follow-up)

<table>
<thead>
<tr>
<th>SF-36 scores after 8 years of follow-up</th>
<th>Baseline physical activity during leisure time</th>
<th>Change in physical activity level from baseline to the 4 years of follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T1</td>
<td>T2</td>
</tr>
<tr>
<td></td>
<td>Decrease</td>
<td>Maintain or increase</td>
</tr>
<tr>
<td>Physical functioning</td>
<td>91.8 (89.9 to 93.7)</td>
<td>92.4 (90.8 to 94.1)†</td>
</tr>
<tr>
<td>Role physical</td>
<td>87.8 (82.8 to 92.8)†</td>
<td>88.4 (84.1 to 92.4)†</td>
</tr>
<tr>
<td>Bodily pain</td>
<td>76.6 (72.6 to 80.5)</td>
<td>77.6 (74.1 to 81.0)†</td>
</tr>
<tr>
<td>General health</td>
<td>70.1 (67.5 to 72.7)</td>
<td>71.3 (69.0 to 73.6)†</td>
</tr>
<tr>
<td>Vitality</td>
<td>62.5 (59.7 to 65.4)</td>
<td>64.5 (62.0 to 67.0)†</td>
</tr>
<tr>
<td>Social functioning</td>
<td>87.6 (84.9 to 90.4)</td>
<td>90.2 (87.8 to 92.7)*</td>
</tr>
<tr>
<td>Role emotional</td>
<td>86.6 (81.3 to 91.9)</td>
<td>88.4 (83.8 to 93.0)†</td>
</tr>
<tr>
<td>Mental health</td>
<td>73.2 (70.7 to 75.7)</td>
<td>76.2 (74.0 to 78.4)*</td>
</tr>
</tbody>
</table>

SUN study participants (N=4206). Adjusted for age, sex, baseline body mass index, history of chronic diseases (cancer, cardiovascular disease and diabetes), smoking status and SF-36 score in Q_4. p for analysis of covariance (ANCOVA).

*Statistically significantly higher (p<0.05) than the lowest level of physical activity (T1 in Q_0 and decreased activity during follow-up) (Benjamini–Hochberg post-test correction).
†Statistically significantly higher (p<0.05) than T2 in Q_0 and decreased during follow-up (Benjamini–Hochberg post-test correction).
‡Statistically significantly higher (p<0.05) than T3 in Q_0 and decreased during follow-up (Benjamini–Hochberg post-test correction).
and bipolar conditions.\textsuperscript{40–43} In this regard, the positive effect of LTPA on mental health was recently analysed in the SUN Project.\textsuperscript{43} In a longitudinal analysis, participants with both high level of LTPA and low level of a sedentary behaviour obtained significant reductions (25\%) in the risk of mental disease.\textsuperscript{43} The mechanisms implicated in these effects could include the improvement of some biological risk factors related to mental health disorders such as dyslipidaemia, glucose intolerance, inflammation and vascular dysfunction.\textsuperscript{44} Moreover, PA increases the proliferation of brain endothelial cells and angiogenesis throughout the brain,\textsuperscript{45} releases endorphins and increases epinephrine and norepinephrine synthesis.\textsuperscript{46} On the other hand, the practice of regular exercise produces some psychological benefits such as the development of positive self-regard, which is likely to play some role in the depression-reducing effects of exercise.\textsuperscript{47} 

PA and physical fitness has been associated with HRQL.\textsuperscript{48–50} A recent systematic review on the association between PA and HRQL in the general population informed that this association varies across HRQL dimensions, with higher physical functioning and vitality being more consistently associated with higher PA levels.\textsuperscript{50} In our study, the SF-36 scores for seven of the eight domains were statistically significant according to quintiles of LTPA. In agreement with our findings, the mentioned review provides support for a dose–response relationship between LTPA level and better HRQL.

The association between LTPA and HRQL found in longitudinal analyses seems to be weaker. Few randomised trials have been carried out to study this issue.\textsuperscript{24–27} In general, a positive effect of LTPA has been found, especially for increments in vitality scores.\textsuperscript{24–26} However, some quality problems have been detected in these studies such as the lack of compliance of participants or differences in baseline scores between groups.\textsuperscript{50}

Regarding observational studies, Malmberg \textit{et al} found that participants in the lowest level of PA at baseline reported poorer perceived health after 10 years of follow-up in a nested case–control study. On the other hand, Herman \textit{et al} did not find a long-term effect for youth PA on adult HRQL in a longitudinal analysis (22-year follow-up) of a small cohort of youths. However, HRQL was not ascertained at baseline in any of the mentioned studies. Subsequently, despite long follow-up periods, a causal relationship cannot be established. Tesser et al concluded that the long-term association between LTPA and HRQL changes is limited. On the other hand, Wendel-Vos \textit{et al} have demonstrated that the change in LTPA over time is predominantly associated with improvement in the mental component of HRQL. However, these two studies used simultaneous assessments of changes in LTPA and changes in HRQL, which raises the possibility that changes in HRQL preceded change in activity or that underlying conditions caused both changes. This limitation was corrected in the Nurses’ Health Study where a correct temporal sequence was established.\textsuperscript{52} Wolin \textit{et al} reported results that extend previous cross-sectional findings to show a direct association between LTPA and HRQL in a way that women who increased their LTPA levels during 10 years also increased their HRQL, providing evidence for an association between long-term changes in LTPA and several aspects of HRQL. This is in agreement with our data that show that subjects with a decrease of LTPA over a 4-year period did not experience the increase in quality of life experienced by those who maintained or augmented their LTPA.

Our results showed a stronger relationship between changes in LTPA and HRQL mental components than with physical components. Vitality, social functioning, role emotional and mental health were associated with the maintenance or increase in LTPA in the present study. Similar findings were reported by previously mentioned studies.\textsuperscript{30, 31} There is a debate on how to define meaningful differences on the SF-36 scores in a clinical setting. Changes in 3, 5 and 10 points have been suggested as being clinically significant for clinical populations.\textsuperscript{38} In the present study, a ≥3-point difference was obtained for physical functioning, general health, role emotional and mental health dimensions whereas a higher and clearly clinically relevant difference (≥5) was obtained for vitality in participants belonging to the highest quintile of LTPA as compared with subjects belonging to the first quintile. Given the characteristics of our cohort that did not include patients, but healthy and relatively young adults, the practical significance of these differences should be even higher.

The strengths of our study include a large sample size, long-term follow-up (8 years), the use of validated questionnaires and sufficient statistical power. On the other hand, several limitations can be considered. First, the SUN Cohort Study is based on university graduates with high educational level and socioeconomic status (SES). SES is commonly associated with healthier lifestyles. However, it is unlikely that this fact may provide any alternative explanation of the reported associations because (1) the homogeneity of participants with regard to SES is a classical method in epidemiology (ie, restriction) to better control confounding; (2) a higher educational level of participants in a cohort ensures a higher validity in self-reported information; and (3) the analyses were adjusted for several confounders such as smoking or body mass index and the magnitude of the associations remained as clinically relevant. Second, apart from PA during leisure time, occupational and household PA might also affect HRQL although participants’ educational profile indicates that the contribution of these types of PA on HRQL could be low. Third, HRQL was collected after 4 (Q_4) and 8 years (Q_8) of follow-up but not at baseline. So, the possibility of reverse causality could be thought of as an alternative explanation for our results. Nevertheless, the analysis for HRQL after 8 years of follow-up was adjusted for HRQL scores obtained in Q_4 and, therefore, our design allows for a correct temporal sequence.

In conclusion, our findings suggest a direct association between long-term changes in LTPA and several aspects of HRQL (especially in relation to mental domains) extending the cross-sectional findings. Additionally, our data suggest that LTPA should be sustained or increased if the positive effect of an active lifestyle on HRQL needs to be maintained.

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REFERENCES