# Trajectories of low-back pain from adolescence to young adulthood

Pieter Coenen PhD[1], Anne Smith PhD[1], Markus Paananen PhD[2], Prof Peter O'Sullivan PhD[1], Darren Beales PhD[1], Prof Leon Straker PhD[1]

[1] School of Physiotherapy and Exercise Science, Curtin University, Perth, Australia.
[2] Centre for Life-Course Epidemiology, and Medical Research Center Oulu, Oulu University Hospital and University of Oulu, Oulu, Finland.

**Corresponding authors**
Professor Leon Straker
School of Physiotherapy and Exercise Science, Curtin University
GPO Box U1987, Perth, WA 6845, Australia
Tel: +61 8 9266 3634
Fax: + 61 8 9266 2605
E-mail: L.Straker@curtin.edu.au

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## Abstract

*Objective*: Despite its high prevalence and burden, understanding of the course of disabling low-back pain (LBP) during the transition from adolescence to adulthood is limited. The aim of this study was to identify and describe trajectories of LBP and its impact among a general population sample followed from adolescence to young adulthood.

*Methods*: Data from follow-up assessments at years 17, 20 and 22 of the Western Australian Pregnancy Cohort (Raine) Study were used (n=1,249). Self-reported LBP and its impact on daily life were assessed, and latent class analysis used to identify clusters. Resultant clusters were profiled on gender, waist circumference, diagnosed co-morbid pain and health related quality of life.

*Results*: Four clusters were identified: A cluster of participants with consistently low prevalence of LBP and its impact (53%) during the period from adolescence to young adulthood, a cluster with an increase in prevalence of LBP and its impact (22%), a cluster with a decrease in prevalence of LBP and its impact (15%); and a cluster with consistently high prevalence of LBP and its impact (10%). These clusters differed markedly on the profiling variables.

*Conclusion*: The identified clusters provide unique information on LBP and its impact during the transition from adolescence to young adulthood. Consideration of these trajectories may be important for the design of early prevention and management strategies.

**Significance & Innovation**

- Four clusters of low-back pain and its impact among participants that were followed from adolescence into young adulthood were identified, reflecting Low, Increasing, Decreasing and High trajectories of prevalence of low-back pain and its impact

- Clusters were profiled across a range of variables and differed markedly on these variables, highlighting the construct validity and clinical relevance of these clusters.
- 15% of the sample followed an improving health trajectory, suggesting the positive natural history of low-back pain for this group.
- 30% of the sample displayed a substantial and/or growing burden due to low-back pain at 22 years underlining the need for targeted early prevention and management of low-back pain.

Low-back pain (LBP) is highly prevalent (1) and is the worldwide leading cause of years lived with disability (2). LBP places a large burden on our society (3) through care seeking and medication use (4), work disability (5), sick leave (6) and early retirement (7). However, current attempts for effective prevention and management of LBP have had only limited success (8, 9). This has resulted in calls for a more detailed knowledge of the aetiology and development of the disorder, particularly early in its development, to better target intervention (10).

A gap in the knowledge on the aetiology and development of LBP is the limited consideration of the time course of LBP. As LBP rarely happens in a single instance (11), the long-term course of LBP should be considered (10). Longitudinal research in adult populations has identified the presence of different LBP trajectories over time (11, 12), with persistent mild, recovering, fluctuating and severe chronic patterns of pain. These different trajectories suggest that the experience of LBP varies considerably between people over time.

To date there is a clear knowledge gap concerning LBP trajectories across the transition from adolescence into adulthood. LBP prevalence commonly increases across adolescence (13) and reaches adulthood levels around the age of 18 (14), with adolescent LBP being a strong predictor of LBP later in life (10). While the time course of LBP from adolescence to young adulthood has been described by measurements eight years apart (15), tracking the course of LBP over multiple time-points has not been performed. Moreover, the impact of LBP across this time course is relatively unknown. While for some people LBP is benign, for others it becomes chronic (16) and disabling (4). Although the clinical relevance of LBP in adolescence has been questioned (17), we have previously identified that at 17 years of age, 20 to 30% of the general population report LBP associated

with negative impacts such as taking medication, seeking care, and modifying physical activity and activities of daily living (4).

To address these knowledge gaps, the first aim of our study was to identify clusters of LBP and its impact among participants in a population-based cohort during the transition from adolescence to young adulthood. In line with trajectories of LBP that have been identified before (11, 12), we hypothesise the existence of different trajectories of LBP and its impact. Our second aim was to profile the identified clusters based on a range of factors known to be associated with disabling LBP in adolescents and young adults, and available in the sample throughout the period from adolescence to young adulthood. These included sex, comorbid pain, psychological, physical and demographic factors. For example, LBP prevalence is higher in females compared to males, even among adolescents (18). Associations of neck pain and headaches with LBP (19) may be due a shared pain mechanism across body areas. The psychological and broad health impact of LBP has been previously reported in both adolescent and adult populations (20) and is captured in the association of mental health related quality of life (HRQoL) and LBP (17). The relationship between adiposity and LBP in this age group (21), may reflect both loading and metabolic or inflammatory influences (22). Gender, adiposity, co-morbid pain and mental HRQoL therefore reflect relevant constructs in the multi-dimensional nature of LBP. It was hypothesised that identified clusters would differ in profile using these multi-dimensional variables, providing construct and clinical validity of identified clusters.

## Methods

*Participants*

Data for this study were obtained from the Western Australian Pregnancy Cohort (Raine) Study (www.rainestudy.org.au). In short, this long-term study began as a pregnancy cohort in which a total of 2,900 women were enrolled whilst attending antenatal clinics in Perth, Australia between 1989 and 1991. Families of the 2,868 children born to 2,826 mothers were invited to participate in regular follow-up assessments. At birth the Raine cohort was representative of those presenting to the recruitment clinics (23) with higher rates of first time mothers, unmarried mothers and lower birth weight compared with Western Australian births, as would be expected at a major women's and infant's hospital. To assess overall cohort attrition bias across a broad range of sociodemographic characteristics, families of active participants at 17 years of age were compared to Western Australian families with similar aged children and active participants at 20 and 22 years of age were compared with Western Australian individuals the same age. Whilst remaining broadly representative, the active cohort has a slightly lower proportion of low socioeconomic status participants (unpublished data). The majority of the cohort was Caucasian, both at birth and at 22 years of age (i.e., 93% had at least one Caucasian parent).

Ethics approval was obtained from the University of Western Australia, Princess Margaret Hospital Human Research Ethics Committee and/or Curtin University human research ethics committees (HR84/2005, HR67/2013; RA/4/1/5202; RA/4/1/2646). The study was conducted in accordance with the Declaration of Helsinki and informed consent was obtained from the primary care-givers (with assent from participants) at year 17, and at year 20 and 22 from the participants themselves.

At ages 17, 20 and 22, participants completed a questionnaire assessing LBP, impact of LBP and several associated variables, and completed a physical assessment protocol. A total of 1,050, 1,113 and 1,033 participants reported on their LBP status and its impact at years 17, 20 and 22 respectively. For the current study, data were used from those 1,249 participants from whom data on their status of LBP and its impact were available for at least two of these three measurement occasions. A comparison of this sample at year 22 with contemporaneous Western Australians (2011 Census data) showed that, compared to the Western Australian population, our study sample remained representative, though with relatively more students, participants were working fewer hours per week and had lower incomes (Appendix 1).

*Data collection*

LBP was assessed using the Nordic Musculoskeletal pain questionnaire (24), that was modified to questioning about pain in the last month and has previously been used in adolescents (4). The impact of LBP in the last month was assessed across five items: sought professional advice or treatment for LBP, took medication to relieve LBP, missed school or work due to LBP, LBP interfered with normal activities and LBP interfered with recreational physical activities (see Table 1 for exact phrasing). These impacts are known to be associated with LBP disability (25) and have been shown to be of importance in adolescence (4).

As a metric for adiposity, waist circumference was measured at the level of the umbilicus with the average of two measurements used for analysis. Diagnosed co-morbid pain was assessed with participants asked whether they have now or in the past ever had health professional–diagnosed neck pain or migraine/severe headache. HRQoL was assessed

with the 36-item Short Form Health Survey (SF-36) at age 17 and the 12-item Short Form Health Survey (SF-12) at ages 20 and 22. The survey provides a physical component summary score (PCS) and a mental component summary score (MCS) (26) and has been validated previously (27). To harmonize outcomes over the different years, weighting factors were used to normalize PCS and MCS on a 0 to 100 scale, with a lower score reflecting a poorer HRQoL (28). Although the aim of this study was to profile potential clusters on mental HRQoL to provide construct and clinical validity of these clusters, we also report on physical HRQoL. Due to the shared constructs of physical HRQoL and the LBP and its impact clusters (e.g., interference with normal and physical activities), this would provide us with methodological validity of the identified clusters.

*Data-analysis*

Change in LBP prevalence and its impact over time in the study sample was assessed using binominal logistic regression with generalized estimating equations (GEE) with time (17, 20 and 22 years) as a categorical independent variable using an exchangeable. Six separate logistic regression models were estimated, with LBP prevalence and each of the five LBP impacts being dichotomous dependent variables.

Secondly, to explore the existence of different trajectories for the experience of LBP and its impact over time, repeated measures latent class analysis (LCA) for binary outcomes was performed (29). LCA is a probabilistic form of cluster analysis which, in this case was used to estimate distinct groups of participants with similar patterns on multiple binary indicators of prevalence of LBP and its impact over the three time-points. Indicator variables thus included the six variables (i.e., one LBP and five impact items) at each of the three time-points. Models were estimated for one to six latent class solutions, allowing for local

dependence of indicators as specified (30). Models were compared using model fit statistics (Akaike and Bayesian Information Criterion; AIC and BIC) and posterior probability diagnostics. Also, entropy R-squared values (the average posterior probabilities after individuals have been assigned to their most likely class) were estimated. Here, values closer to 1 (range 0 to 1) indicate greater precision (31). The optimal model was chosen based upon parsimonious data fit statistics (32) along with consideration of the clinical meaning and interpretability as well as the numbers available in each cluster for subsequent statistical analysis of each fit (31). In cases where the addition of another latent class would have only small improvements to the model fit, the most parsimonious model was chosen based on all these factors. Participants were assigned to the latent class for which they had the maximum posterior probability of membership.

Resultant clusters from the optimal LCA model were profiled based on gender, waist circumference, co-morbid pain and HRQoL. Regression analyses were conducted to assess the differences between clusters for each of these variables (across all clusters and comparing all clusters with one another), using cluster membership as a categorical independent variable. Variables were screened for normality using histograms and diagnostic measures. In all regression analyses, associations were adjusted for gender. Linear regression was used for continuous variables (waist circumference and HRQoL), and regression coefficients (beta; with 95% confidence interval, CI) and gender-adjusted means were calculated to describe differences between clusters. Logistic regression was used for binominal variables (gender and co-morbid pain), and odds ratios (OR; with 95% CI) and gender-adjusted prevalence were calculated to describe differences between clusters. P-values<0.05 were considered statistically significant (2-sided). LCA was performed with Latent GOLD (Statistical Innovations Inc, Belmont, MA) while all other statistical procedures

were performed using Stata (StataCorp. 2013. *Stata Statistical Software: Release 13.* College Station, TX: StataCorp LP).

## Results

Prevalence of LBP over the past month significantly increased from 32% in year 17, to 45% in years 20 and 22 (Table 1). All five variables describing the impact of LBP also increased significantly over time with proportions of participants reporting an impact ranging from 6% in year 17 to 25% in year 22.

Four clusters were identified as the best fit for describing trajectories of LBP and its impact from adolescence to young adulthood (Figure 1). These reflected; a cluster with consistently low probability of LBP and its impact over the three time-points ('Low', n=661, 53%), a cluster with an increase in both LBP and its impact of LBP prevalence over the period ('Increasing', n=272, 22%), a cluster with moderate prevalence at 17 and 20 that reduced at 22 ('Decreasing', n=192, 15%); and a cluster with consistently high prevalence of LBP and its impact ('High', n=124, 10%). All clusters had a high average posterior probability (SD) for cluster membership of ≥0.95, being 0.95(0.09), 0.95(0.09), 0.98(0.05) and 0.96(0.09) for the Low, Increasing, Decreasing and High clusters respectively. Only 11% of the participants had a probability of membership for their assigned cluster of less than 0.90.

Clusters were profiled for participants who had complete data over the three measurement occasions for gender (n=1249), waist circumference (n=740), co-morbid pain (n=766) and HRQoL (n=649). Profiles showed that the proportion of women was higher in the Increasing and Decreasing clusters as compared to the Low cluster, and was even higher in the High cluster (Table 2). Waist circumference was only significantly higher in the Increasing cluster compared to the Low cluster at 20 years of age (Table 2). However, trends suggest a late onset increase in waist circumference for the Low and Decreasing clusters and a steady increase in waist circumference for the Increasing and High clusters. The prevalence of diagnosed migraine/headache and neck pain were in general higher in the

Decreasing and High clusters as compared to the Low cluster (Table 2). For diagnosed migraine/headache, a late onset increase in prevalence was observed for the Increasing cluster with a significant difference from the Low cluster at 22 years of age. For diagnosed neck pain, a comparable pattern was seen. However for the Decreasing cluster, a tendency for a decrease in diagnosed neck pain prevalence was observed with a significantly lower prevalence of neck pain compared to the High cluster at 22 years of age. The physical and mental HRQoL were in general the lowest in the High cluster as compared to the other clusters (Table 3). For physical HRQoL, scores were in general lower in the Increasing and Decreasing clusters when compared to the Low cluster. For mental HRQoL, a comparable pattern was seen except that the Decreasing cluster was not significantly lower than the Low cluster at 22 years of age.

## Discussion

It was shown that the prevalence of LBP *and* its impact of LBP increased significantly over a period from late adolescence to young adulthood. Whilst an increase in LBP prevalence has been shown in previous work within this age group (13, 14), the demonstration of a growing impact of LBP during the transition from adolescence to young adulthood is novel.

We identified and profiled four different trajectories of the natural course of LBP and its impact reflecting: a group of participants with consistently low prevalence of LBP and its impact ('Low' cluster), a group with an increase in prevalence of LBP and its impact over time ('Increasing' cluster), a group with a decrease in prevalence of LBP and its impact between the age of 20 to 22 years ('Decreasing' cluster) and a group with consistently high prevalence of LBP and its impact across all time-points ('High' cluster). These clusters provide valuable information for LBP prevention and management. The Increasing and High clusters, representing 30% of this cohort, are of particular importance as they are associated with a substantial and growing health burden by 22 years. This information suggests that clinical interventions targeting these groups in adolescence could reduce the life-course burden of LBP.

The Decreasing cluster, a group that has not been previously identified, is also particularly interesting as it suggests that for some individuals, adolescent LBP may be benign and attenuates when reaching adulthood, even without clinical interventions. This underlines that the natural history of LBP for this group is positive during the transition from adolescence to young adulthood and presumably this group of individuals may not require treatment. Being able to identify those individuals in this cluster could save personal and community costs associated with unnecessary interventions, and prevent iatrogenic disability (33). Transitions from a negative to a positive health outcome have been shown

before for other health outcomes such as asthma (34) and may be due to important transitions in life taking place during the period from adolescence to adulthood (e.g., changes in work situation, relationships and sport participation) (35, 36). However, the apparent attenuation could also be due to a long-term fluctuation of pain not detected in our study.

Attempts to describe trajectories of LBP using cluster analysis have been reported on before in general populations of adults in which LBP was assessed five years apart (11) and weekly during a one year period (12). These studies identified groups of participants with low, short term, persistent and fluctuating levels of LBP. Trajectories of LBP have also been described in sample of 11 to 14 year olds with measurements every three months during three years (37) identifying 6 different trajectories, including high, low, and different increasing and decreasing LBP groups. However these adolescents were not tracked through to adulthood. The only study that has tracked LBP status of adolescents through to adulthood collected data at just two time-points separated by an eight year time gap. Whilst this study did not allow for trajectory analysis, it did identify groups without LBP, with persistent LBP and with changing levels of LBP (15). Our findings support the presence of different trajectories of LBP including High, Low, Increasing and Decreasing groups, broadly in line with adult studies (11, 12), suggesting that certain adult LBP trajectories may have their origin early in life.

*Trajectory profiles*

The four identified clusters differed markedly across profiling factors (i.e., gender, adiposity, diagnosed pain co-morbidities and HRQoL). The clear differences in these relevant factors provide construct and clinical validity of the identified clusters. However from our results it

cannot be concluded whether the associated factors should be considered predictors or outcomes of the identified clusters. Our findings however support that there is considerable variability in LBP, its impact and associated factors, especially over the period of time from adolescence to young adulthood. A relatively large cluster of participants in our cohort (53%) displayed a consistently low prevalence of LBP and its impact. Compared to the other clusters, this group consisted of a relatively low proportion of females, participants had relatively low adiposity, co-morbid pain was relatively low and participants scored relatively well on HRQoL. Such a cluster of pain free participants with a comparable profile has been reported on before among adolescents and young adults (11, 37).

In contrast, the cluster with a persistent high prevalence of LBP and its impact consisted of a high proportion of females, with relatively high levels of co-morbid neck pain, headaches and poorer HRQoL. The association of LBP with these factors is in line with earlier work in adolescents and young adults showing that LBP is associated with gender (38), adiposity (39), co-morbidities (e.g., mental and physical health issues, including neck pain; 36, 40) and mental health issues (including depression, anxiety (38) and somatic complaints (37)), reflecting the multi-dimensional nature of LBP (41). Our finding that this cluster comprised approximately 10% of the sample is in line with earlier work on adult populations (11). This group is however substantially larger than a comparable group only being 1% of the sample in a study among 11 to 14 year olds (37).

The Increasing and Decreasing clusters had opposing, though non-significant, patterns of waist circumference and neck pain, but similar patterns of slightly increased proportions of women (i.e., 62% and 57% respectively), and sustained higher levels of migraine and headache. It is interesting that although the Decreasing cluster had no LBP with impact at year 22, the prevalence of headache and migraine remained high. This

suggests an emerging group in young adulthood with headache in the absence of LBP, that has as far as we aware not been previously reported. Regarding HRQoL, a comparable phenomenon was observed as participants in the Decreasing cluster remained affected in their physical HRQoL while their mental HRQoL scores attenuated towards levels of the Low cluster at year 22.

*Methodological limitations*

A general limitation of the use of LCA is that people are categorized into clusters based upon average patterns and a balance is necessitated between model parsimony and interpretability, versus identifying smaller groups with more between-group variability. There is no one preferred method of deciding on an optimal number of clusters. Therefore, the four clusters we chose may not reflect the total variation in the pathways of LBP and its impact in our sample of adolescents and young adults. However, the average probability of membership of the clusters was high (>0.95) and only 11% of the participants had a probability of membership for their assigned cluster of less than 0.90. This affords reasonable confidence that the clusters identified in this study provide a good representation of the trajectories of LBP and its impact in our sample.

The population-based cohort in this study was subject to drop-out with a total of 1249(43%) participants of those who initially entered the cohort at birth being analysed in the current study. Despite this, the analysed sample showed reasonable similarities when compared to the Western Australian population at age 22 years (Appendix 1), although there were relatively more students, participants were working fewer hours per week and had lower incomes. However, as characteristics of the Western Australian population may differ from those in other regions, generalization from our results should be done with due

caution. For example, waist circumferences in our study (i.e., mean and SD of 78.5(10.6) cm over all participants at year 17) are somewhat higher than waist circumferences reported for European (i.e., mean and 95% confidence interval in Finnish 17 year olds of 75.9 [62.5, 108.1] cm (42) and mean and SD and among Greek 17 year old boys of 74.8(7.8) and girls of 68.7(7.9) cm (43)) and US populations (i.e., median and 80% confidence interval for 17 year old boys of 77.6 [69.1 101.8] cm and girls of 76.5 [67.3 98.0] cm (44)). Extrapolation of current results to other samples needs to be investigated with due consideration of the characteristics of our sample, such as the majority of the participants being Caucasian.

HRQoL was measured with the SF-12 and SF-36, and for both questionnaires there is evidence of validity in populations of young adults (12 item (45), 36 item (46, 47)). Although we were not able to identify studies on the validity of this questionnaire in general populations of 17 year olds, the questionnaire has been constructed for self-reports of participants 14 years and older according to original authors of the scale (26). However, as HRQoL is known to be dependent on age (48), the use of this questionnaire in 17 year olds may be a source of bias in our study. Moreover, while the 36 item questionnaire is more comprehensive and thus sensitive to pick up differences between or within subject, the SF-12 is also known to capture the constructs of mental and physical HRQoL with a reasonable accuracy (49). To minimize this risk of certain biases, HRQoL composite scores (rather than sub-category scores) were used, HRQoL were normalized and no statistical comparisons were performed testing for differences in HRQoL over time.

## Conclusion

We identified four clusters of LBP and its impact among participants that were followed from adolescence into young adulthood. These clusters reflect groups with Low, Increasing, Decreasing and High prevalence of LBP and its impact. Clusters were profiled across a range of variables and differed markedly on these variables, highlighting the construct validity and clinical relevance of these clusters. Whilst 15% of the sample followed an improving health trajectory, 30% of the sample displayed a substantial and/or growing burden due to LBP at 22 years underlining the need for targeted early prevention and management of LBP in this group.

## Disclosure of interest

All authors (Pieter Coenen, Anne Smith, Markus Paananen, Peter O'Sullivan, Darren Beales and Leon Straker) did not report on receiving any monetary compensation (including consulting fees, speaking fees or honoraria). There were no other conflicts of interest declared by the authors.

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Table 1. Prevalence of low-back pain (LBP) and its impact at years 17, 20 and 22 in the study sample. P-values represent the change in prevalence of LBP or LBP impact over time obtained from GEE analyses, with the reference year for group contrasts across rows indicated. Statistically significant differences are depicted with a *.

| | | Year 17 | Year 20 | Year 22 |
|---|---|---|---|---|
| Number of participants | n | 1,050 | 1,112 | 1,033 |
| Has your low-back been painful at any time in the last month? | number of cases (%) | 337 (32%) | 497 (45%) | 467 (45%) |
| | p-value | Reference | <0.01* | <0.01* |
| | | | Reference | 0.94 |
| Have you sought health professional advice or treatment for low-back pain? | number of cases (%) | 122 (12%) | 172 (15%) | 228 (22%) |
| | p-value | Reference | <0.01* | <0.01* |
| | | | Reference | <0.01* |
| Have you taken medication to relieve the low-back pain? | number of cases (%) | 117 (11%) | 176 (16%) | 217 (21%) |
| | p-value | Reference | <0.01* | <0.01* |
| | | | Reference | <0.01* |
| Have you missed work or study due to the low-back pain? | number of cases (%) | 67 (6%) | 84 (8%) | 106 (10%) |
| | p-value | Reference | 0.19 | <0.01* |
| | | | Reference | 0.02* |
| Has the low-back pain interfered with your normal activities? | number of cases (%) | 128 (12%) | 193 (17%) | 253 (24%) |
| | p-value | Reference | <0.01* | <0.01* |
| | | | Reference | <0.01* |
| Has the low-back pain interfered with recreational physical activities? | number of cases (%) | 144 (14%) | 198 (18%) | 254 (25%) |
| | p-value | Reference | <0.01* | <0.01* |
| | | | Reference | <0.01* |

Table 2. Gender, waist circumference, diagnosed migraine or headache and diagnosed neck pain stratified by cluster. Number of participants (with prevalence in %) for dichotomous variables and adjusted means (with 95% confidence interval, CI) for continuous variables are shown. Differences between clusters are depicted with odds ratios (OR; with 95% CI for dichotomous variables) or beta (with 95% CI for continuous variables) with the reference cluster for contrasts across rows indicated. Data for waist circumference, diagnosed migraine or headache and diagnosed neck pain are adjusted for gender. Statistically significant differences are depicted with a *.

| Variable | Year | | Cluster 1 Low pain and its impact | | Cluster 2 Increasing pain and its impact | | Cluster 3 Decreasing pain and its impact | | Cluster 4 High pain and its impact | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of participants | | n (%) | 661 (53%) | | 272 (22%) | | 192 (15%) | | 124 (10%) | | 1249 |
| Gender | | Number of females (%) | 298 (45%) | | 166 (61%) | | 108 (56%) | | 94 (76%) | | 666 (53%) |
| | | OR, 95% CI | Reference[1] | | 1.91 | 1.43, 2.54* | 1.57 | 1.13, 2.16* | 3.82 | 2.46, 5.92* | |
| | | | | | Reference | | 0.82 | 0.56, 1.19 | 2.00 | 1.24, 3.23* | |
| | | | | | | | Reference | | 2.44 | 1.48, 4.02* | |
| Waist circumference (cm) | 17 | Mean, 95% CI | 78.02 | 76.92, 79.11 | 78.80 | 77.23, 80.37 | 79.74 | 77.64, 81.85 | 78.78 | 76.27, 81.30 | 78.52 (10.63) |
| | | Beta, 95% CI | Reference[2] | | 0.78 | -1.14, 2.71 | 1.73 | -0.65, 4.11 | 0.77 | -2.01, 3.54 | |
| | | | | | Reference | | 0.94 | -1.67, 3.56 | -0.01 | -2.96, 2.93 | |
| | | | | | | | Reference | | -0.96 | -4.22, 2.31 | |
| Waist circumference (cm) | 20 | Mean, 95% CI | 77.80 | 76.58, 79.02 | 80.59 | 78.83, 82.34 | 79.21 | 76.86, 81.56 | 80.39 | 77.57, 83.20 | 78.93 (12.15) |
| | | Beta, 95% CI | Reference[2] | | 2.79 | 0.64, 4.94* | 1.41 | -1.25, 4.08 | 2.59 | -0.52, 5.70 | |
| | | | | | Reference | | -1.38 | -4.30, 1.55 | -0.20 | -3.49, 3.09 | |
| | | | | | | | Reference | | 1.18 | -2.47, 4.83 | |
| Waist circumference (cm) | 22 | Mean, 95% CI | 81.39 | 80.11, 82.68 | 83.28 | 81.43, 85.13 | 82.59 | 80.11, 85.07 | 82.68 | 79.71, 85.64 | 82.15 (12.88) |
| | | Beta, 95% CI | Reference[3] | | 1.89 | -0.38, 4.16 | 1.20 | -1.61, 4.00 | 1.28 | -1.99, 4.56 | |
| | | | | | Reference | | -0.69 | -3.78, 2.40 | -0.60 | -4.07, 2.86 | |
| | | | | | | | Reference | | 0.09 | -3.76, 3.94 | |
| Diagnosed migraine or headache | 17 | Adjusted prevalence | 4% | | 6% | | 13% | | 12% | | 56 (7%) |
| | | OR, 95% CI | Reference[1] | | 1.38 | 0.62, 3.06 | 3.18 | 1.44, 7.04* | 2.84 | 1.13, 7.18* | |
| | | | | | Reference | | 2.31 | 0.98, 5.45 | 2.06 | 0.79, 5.41 | |
| | | | | | | | Reference | | 0.89 | 0.34, 2.34 | |
| Diagnosed migraine or headache | 20 | Adjusted prevalence | 7% | | 10% | | 16% | | 34% | | 76 (10%) |
| | | OR, 95% CI | Reference[1] | | 1.81 | 0.90, 3.63 | 5.84 | 2.98, 11.45* | 3.47 | 1.55, 7.77* | |
| | | | | | Reference | | 3.23 | 1.62, 6.42* | 1.92 | 0.86, 4.28 | |
| | | | | | | | Reference | | 0.59 | 0.27, 1.31 | |
| Diagnosed migraine or headache | 22 | Adjusted prevalence | 5% | | 9% | | 24% | | 16% | | 104 (14%) |
| | | OR, 95% CI | Reference[1] | | 2.12 | 1.21, 3.71* | 3.41 | 1.83, 6.37* | 3.36 | 1.70, 6.65* | |
| | | | | | Reference | | 1.61 | 0.86, 3.00 | 1.59 | 0.81, 3.10 | |
| | | | | | | | Reference | | 0.99 | 0.48, 2.04 | |
| Diagnosed neck pain | 17 | Adjusted prevalence | 4% | | 17% | | 21% | | 33% | | 90 (12%) |
| | | OR, 95% CI | Reference[1] | | 1.47 | 0.78, 2.77 | 2.45 | 1.23, 4.89* | 6.79 | 3.50, 13.15* | |
| | | | | | Reference | | 1.67 | 0.80, 3.45 | 4.62 | 2.32, 9.17* | |
| | | | | | | | Reference | | 2.77 | 1.32, 5.83* | |
| Diagnosed neck pain | 20 | Adjusted prevalence | 8% | | 16% | | 23% | | 23% | | 94 (12%) |
| | | OR, 95% CI | Reference[1] | | 5.37 | 2.72, 10.59* | 6.97 | 3.30, 14.70* | 12.78 | 5.95, 27.43* | |
| | | | | | Reference | | 1.30 | 0.69, 2.42 | 2.38 | 1.27, 4.46* | |
| | | | | | | | Reference | | 1.83 | 0.91, 3.71 | |
| Diagnosed neck pain | 22 | Adjusted prevalence | 4% | | 24% | | 16% | | 34% | | 107 (14%) |
| | | OR, 95% CI | Reference[1] | | 8.19 | 4.27, 15.72* | 4.73 | 2.15, 10.39* | 13.42 | 6.32, 28.50* | |
| | | | | | Reference | | 0.58 | 0.30, 1.10 | 1.64 | 0.90, 2.97 | |
| | | | | | | | Reference | | 2.84 | 1.35, 5.94* | |

[1]Level of statistical significance depicting the difference across all clusters: P<0.01*
[2] Level of statistical significance depicting the difference across all clusters: P=0.06
[3] Level of statistical significance depicting the difference across all clusters: P=0.03*
[4] Level of statistical significance depicting the difference across all clusters: P=0.07

Table 3. Physical and mental health related quality of life (expressed in physical component summary score (PSC) and mental component summary score (MSC), respectively) stratified by cluster. Adjusted means (with 95% confidence interval, CI) of PSC and MSC are shown and differences between clusters are depicted with beta's (with 95% CI) with the reference cluster for contrasts indicated. Mean scores and beta's are adjusted for gender. Statistically significant differences are depicted with a *.

| **Variable** | **Year** | | **Cluster 1 Low pain and its impact** | | **Cluster 2 Increasing pain and its impact** | | **Cluster 3 Decreasing pain and its impact** | | **Cluster 4 High pain and its impact** | | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of participants | | n (%) | 661 (53%) | | 272 (22%) | | 192 (15%) | | 124 (10%) | | 1249 |
| PSC (Normalised score) | 17 | Mean, 95% CI | 56.30 | 55.54, 57.06 | 54.74 | 53.71, 55.76 | 52.91 | 51.43, 54.40 | 50.00 | 48.37, 51.64 | 54.90 (6.71) |
| | | Beta, 95% CI | Reference | | -1.56 | -2.85, -0.28* | -3.39 | -5.06, -1.71* | -6.30 | -8.12, -4.48* | |
| | | | | | Reference | | -1.82 | -3.63, -0.02 | -4.73 | -6.65, -2.82 | |
| | | | | | | | Reference | | -2.91 | -5.11, -0.71 | |
| PSC (Normalised score) | 20 | Mean, 95% CI | 54.80 | 54.08, 55.52 | 53.80 | 52.84, 54.76 | 54.07 | 52.67, 55.47 | 50.85 | 49.31, 52.38 | 54.05 (6.25) |
| | | Beta, 95% CI | Reference | | -1.00 | -2.20, 0.20 | -0.73 | -2.30, 0.85 | -3.95 | -5.66, -2.24* | |
| | | | | | Reference | | 0.27 | -1.42, 1.97 | -2.95 | -4.75, -1.15* | |
| | | | | | | | Reference | | -3.22 | -5.29, -1.16* | |
| PSC (Normalised score) | 22 | Mean, 95% CI | 55.54 | 54.83, 56.25 | 53.42 | 52.47, 54.37 | 53.86 | 52.47, 55.24 | 50.79 | 49.26, 52.31 | 54.28 (6.37) |
| | | Beta, 95% CI | Reference | | -2.11 | -3.31, -0.92* | -1.68 | -3.24, -0.12* | -4.75 | -6.45, -3.05* | |
| | | | | | Reference | | 0.44 | -1.24, 2.12 | -2.64 | -4.42, -0.85* | |
| | | | | | | | Reference | | -3.07 | -5.12, -1.02* | |
| MCS (Normalised score) | 17 | Mean, 95% CI | 50.11 | 48.96, 51.27 | 48.11 | 46.57, 49.66 | 47.45 | 45.20, 49.71 | 44.60 | 42.12, 47.07 | 48.74 (10.11) |
| | | Beta, 95% CI | Reference | | -2.00 | -3.94, -0.06* | -2.66 | -5.20, -0.12* | -5.51 | -8.27, -2.75* | |
| | | | | | Reference | | -0.66 | -3.39, 2.07 | -3.52 | -6.42, -0.61* | |
| | | | | | | | Reference | | -2.85 | -6.19, 0.48 | |
| MCS (Normalised score) | 20 | Mean, 95% CI | 48.59 | 47.46, 49.72 | 45.39 | 43.87, 46.91 | 45.83 | 43.61, 48.04 | 45.46 | 43.03, 47.89 | 47.10 (9.93) |
| | | Beta, 95% CI | Reference | | -3.20 | -5.10, -1.29* | -2.76 | -5.26, -0.27* | -3.13 | -5.84, -0.42* | |
| | | | | | Reference | | 0.44 | -2.25, 3.12 | 0.07 | -2.78, 2.92 | |
| | | | | | | | Reference | | -0.37 | -3.64, 2.91 | |
| MCS (Normalised score) | 22 | Mean, 95% CI | 47.98 | 46.83, 49.14 | 45.28 | 43.73, 46.83 | 46.25 | 43.99, 48.51 | 45.14 | 42.66, 47.63, | 46.82 (10.09) |
| | | Beta, 95% CI | Reference | | -2.70 | -4.65, -0.75* | -1.73 | -4.27, 0.82 | -2.84 | -5.60, -0.07* | |
| | | | | | Reference | | 0.97 | -1.77, 3.71 | -0.14 | -3.05, 2.78 | |
| | | | | | | | Reference | | -1.11 | -4.45, 2.23 | |

[1] Level of statistical significance depicting the difference across all clusters: P<0.01*

Figure 1. Low-back pain (LBP) and its impact at year 17, 20 and 22 stratified by cluster. Prevalence of LBP and the five impacts of LBP (sought professional advice, took medication, missed of school/work, interference with normal activity and interference with physical activities) is plotted on the vertical axis. Entropy R-squared values for the four-class model was 0.90, which is considered excellent. BIC scores for models with one to six latent class solutions were 16520, 13643, 13132, 12647, 12404 and 12312 respectively while AIC scores were 16412, 13438, 12829, 12247, 11907 and 11716 respectively.