Dissertation

Student ID: 11484265

2025-10-30

rmdwc::rmdcount('Paper.rmd')

tidy up code

Contents

Introduction

Physical inactivity remains a significant global public health concern, with nearly 1.8 billion individuals not meeting recommended levels of physical activity (World Health Organization, 2024), representing a 9% increase over the past two decades (Mitchell, 2019; Strain et al., 2024). Beyond its physiological consequences, insufficient physical activity is a leading risk factor for numerous chronic diseases, including cardiovascular conditions, diabetes, and certain cancers, and contributes to mental health challenges such as depression and anxiety. Participation in physical activity is shaped by social, developmental, and motivational factors, with motivation consistently identified as a central determinant of behaviour (Daley & Duda, 2006; Deci & Ryan, 2008; Duncan et al., 2010).

Understanding the factors that influence physical activity engagement is crucial for developing effective interventions. Motivation plays a central role in determining whether individuals initiate and maintain physical activity behaviours. Theories such as Self-Determination Theory (SDT) and the Theory of Planned Behaviour (TPB) have been instrumental in elucidating the psychological and social factors that underpin physical activity motivation. SDT emphasizes the importance of intrinsic motivation and the satisfaction of basic psychological needs in fostering sustained engagement in physical activity (Brooks et al., 2017). TPB, on the other hand, focuses on how attitudes, subjective norms, and perceived behavioural control influence behavioural intentions and actions.

Despite the valuable insights provided by these frameworks, existing research often examines age-related differences in physical activity motivation within either youth or adult populations, without directly comparing these groups. This approach limits our understanding of how motivational mechanisms may differ across the lifespan and how these differences influence physical activity behaviours. Addressing this gap is essential for designing more age-specific interventions that effectively promote physical activity across various life stages.

This dissertation aims to explore this gap by comparing motivational profiles and their behavioural implications across youth and adult populations.

1. Do perceived exercise motives influence physical activity differently in youths and adults?
2. How do age differences shape dominant exercise motives within youth and adult groups?

To answer these questions, multigroup structural equation modeling (SEM) to test whether the relationships between motives and physical activity differ by age, and latent class analysis (LCA) will be employed to identify distinct motivational profiles within each age group.

Literature Review

Self-Determination Theory (SDT)

SDT is a popular framework that has gained popularity in the past two decades. Developed by Deci & Ryan (2000), it emphasizes the degree to which behaviour is self-determined versus controlled. Motivation is distinguished in terms of autonomy, with autonomous forms associated with volition and self-endorsement of behaviour, and controlled forms reflecting pressure from external contingencies or internalized demands such as guilt or ego involvement. Within SDT, extrinsic motivation is subdivided into external regulation, introjected regulation, identified regulation, and integrated regulation, representing increasing internalization of instrumental behaviours. Intrinsic motivation, by contrast, arises from interest, enjoyment, or inherent satisfaction in the activity itself. These distinctions have implications for physical activity, as more autonomous motives are linked to sustained engagement, positive psychological outcomes, and long-term health (CITE).

SDT has been influential in health behaviour research because it prioritizes the quality of motivation over mere quantity. Empirical evidence indicates that need-supportive interventions can enhance exercise uptake, reduce dropout, and improve both physical and psychological wellbeing (Teixeira et al., 2012; Ng et al., 2012). The framework thus functions both as a descriptive model and as a prescriptive guide for intervention design.

Nevertheless, while SDT posits that autonomy-supportive environments foster intrinsic motivation, recent studies suggest that this relationship may not be as straightforward as previously thought. For instance, interventions designed to enhance autonomy support have shown inconsistent effects on long-term physical activity adherence, possibly due to individual differences in baseline motivation or contextual factors (Trigueros et al). Additionally, the application of SDT in physical activity research often overlooks the role of external constraints and structural factors, such as socioeconomic status, that can impede motivation and behaviour change. These external factors may interact with psychological needs in complex ways that SDT does not fully address.

Theory of Planned Behaviour (TPB)

Proposed by Ajzen in 1991, TPB is a widely used framework for predicting and understanding human behaviour, emphasizing the role of intention as the proximal determinant of action. According to TPB, behavioural intentions are influenced by three key factors: attitudes toward the behaviour, subjective norms, and perceived behavioural control (PBC). Attitudes reflect an individual's positive or negative evaluation of performing the behaviour, subjective norms capture perceived social pressure from significant others to engage or not engage, and PBC represents the perceived ease or difficulty of performing the behaviour, akin to self-efficacy. These factors interact to shape intention, which in turn predicts behaviour, although PBC can also have a direct effect on behaviour. In the context of physical activity, TPB has been used to explain variations in exercise participation across age groups, demonstrating that stronger intentions, supported by favourable attitudes, positive social norms, and higher perceived control, are associated with higher levels of activity. However, the framework also recognizes that intentions do not always translate into behaviour, highlighting the importance of situational constraints and individual capabilities.

Like SDT, TPB has faced several critiques. Its constructs are typically measured through self-report instruments, which are vulnerable to biases such as social desirability and inaccuracies in introspection. Ajzen (2020) highlighted the complexity of assessing the beliefs underlying attitudes, subjective norms, and perceived behavioural control, noting that these measures do not always correspond perfectly with actual behaviour. In addition, TPB primarily focuses on individual-level factors and may insufficiently consider broader social, cultural, or structural influences. Its emphasis on personal perceptions of control can overlook systemic barriers or facilitators that shape behaviour.

Age-Related Differences

Across the lifespan, intrinsic and personally meaningful motivations are consistently associated with higher levels of physical activity. However, intrinsic motivation tends to decline with age (Brunet & Sabiston, 2011; Dishman et al., 2018; de Maio Nascimento, 2023), suggesting that the factors driving engagement shift across developmental stages. Environmental opportunities, such as access to facilities or structured programs, appear to facilitate activity regardless of age, providing a common context that supports engagement across populations.

In youths, intrinsic motivation, enjoyment, and social support are strong predictors of habitual physical activity. Longitudinal evidence indicates that adolescents who maintain higher intrinsic motivation and personally meaningful goals, particularly those emphasizing enjoyment, remain more active over time, whereas declines in social, competence, or appearance goals can weaken engagement (Dishman et al., 2018). However, these findings are limited to students from two school districts in South Carolina, which may reduce generalizability. Cross-sectional studies further show that higher motivation profiles in adolescents are linked to adaptive outcomes such as responsibility, resilience, and social support (Heredia-León et al., 2023), although teacher presence during data collection may have influenced student responses.

Adults frequently report exercising for reasons aligned with personal health, fitness, and psychological well-being (Brunet & Sabiston, 2011; Nascimento et al., 2023). Relaxation and stress relief have also been highlighted as important motivating factors, contributing to voluntary adherence and psychological benefits. These motives appear to remain relatively stable across younger and older adults (de Maio Nascimento, 2021; Vuckovic, 2015; Kilgour, 2005). While specific motives vary by age, some contextual factors influence physical activity similarly across age groups. Access to facilities, opportunities to participate, and supportive environments facilitate engagement across the lifespan, providing a baseline influence independent of age-specific motivational differences (Brunet & Sabiston, 2011; Dishman et al., 2018).

Several methodological limitations constrain these findings. Brunet and Sabiston (2011) reported high inter-correlations between intrinsic motivation and identified regulation, suggesting potential multicollinearity that may obscure distinct motivational effects. De Maio Nascimento et al. (2021) acknowledged that recruitment from a single region, uneven group sizes, and the absence of objective fitness measures limit generalizability. Vuckovic et al. (2015) noted a relatively small subgroup of participants engaged in group or personal training, lack of recorded exercise intensity and frequency, and cultural specificity to Slovenia, all of which restrict external validity. Finally, Kilgour et al. (2005) highlighted that their synthesis, restricted to adults over 70, could not be quantitatively integrated and that the uneven inclusion of motivational factors across studies may over- or under-represent certain influences.

Nevertheless, these studies suggest clear age-related differences in the influence of specific motives. Enjoyment, social, and guilt motives are especially relevant for youths, whereas fitness- and relaxation-related motives are more salient in adults. Environmental opportunities appear to exert a similar influence across age groups. While motivational profiles were identified, the differential predictive power of these motives on physical activity across youth and adult populations is rarely directly quantified. Addressing this allows for a more nuanced understanding of which motives are most influential at different developmental stages.

Hypothesis 1: The influence of exercise motives on physical activity differs between youths and adults.

- H1(a). Enjoyment, social, and guilt motives are more influential in youths than in adults.
- H1(b). Fitness and relaxation motives are more influential motives in adults than in youths.
- H1(c). Environmental opportunities influence physical activity similarly across age groups.

Motivational Profiles

Motivational profiles provide a person-centred perspective on the heterogeneity of exercise motives, capturing combinations of autonomous and controlled regulation within individuals. In adults, Ostendorf et al. (2021) identified three primary motivational profiles among individuals with overweight or obesity: high autonomous, high combined, and moderate combined. The high autonomous profile was characterized by strong intrinsic and identified motivations, with minimal influence of external or introjected regulation. The high combined profile reflected elevated levels across all regulatory types, while the moderate combined profile exhibited intermediate levels on all regulations. Longitudinally, individuals in the high autonomous profile demonstrated the least decline in moderate-to-vigorous physical activity during transitions from supervised to unsupervised exercise, suggesting that intrinsic and identified motivations support sustained engagement, whereas moderate-to-high external regulation may require additional support for continuity. However, the findings were based on a relatively small, predominantly female, non-Hispanic White sample enrolled in a structured weight-loss program, limiting generalizability to other demographic groups or less motivated individuals. Similarly, Nuss et al. (2023) identified four motivational profiles in Canadian adults, indicating that combinations of controlled and autonomous motivation may synergistically support activity, while low overall motivation corresponded to minimal engagement. Yet reliance on retrospective self-reports of physical activity, including pre-pandemic behaviour, introduces potential recall and overreporting bias.

In adolescents, Moreno-Murcia et al. (2011) found two primary motivational profiles in physical education students: a self-determined profile, with high intrinsic and identified motivation, and a non-self-determined profile, with elevated external, introjected, and amotivated scores. The self-determined profile was positively associated with TPB constructs such as intention, subjective norm, PBC, and attitude, indicating that higher autonomous motivation supports favorable cognitions and participation behaviours. Cross-sectional studies further corroborate these trends. Similarly, Heredia-León et al. (2023) identified higher motivation profiles among adolescents aged 12–16, which were associated with adaptive outcomes such as responsibility, resilience, and perceived social support. They also reported that students with high-quality and high-quantity motivational profiles demonstrated greater intention to be physically active and enjoyment in PE classes, whereas low-quality profiles corresponded to higher boredom and lower engagement. Tapia-Serrano et al. (2022) identified five profiles in children, ranging from highly amotivated to autonomously motivated, showing that even controlled motivation can promote short-term engagement, though autonomy supports more sustained activity. However, the sample consisted of non-representative Spanish children, limiting generalizability. Moreover, the inclusion of integrated regulation, typically observed in more mature individuals (Vallerand, 1997), may have introduced construct overlap within this age group.

While these studies collectively demonstrate heterogeneity in motivation, they vary in sample characteristics, activity settings, and statistical methods for extracting latent profiles, complicating direct comparisons across age groups. Few studies have examined whether the same latent structures are consistent between youths and adults, or whether increasing age systematically influences profile membership. Investigating these patterns using comparable data across youths and adults will provide a clearer understanding of the role of age.

Hypothesis 2: Distinct motivational profiles exist within youths and within adults.

- H2(a). With increasing age, the likelihood of adults belonging to classes with lower overall agreement across motivational items increases, reflecting a gradual decline in motivation, with the oldest adults showing the steepest decrease.
- H2(b). With increasing age, the likelihood of youths belonging to classes with lower overall agreement across motivational items increases, reflecting a gradual decline in motivation.

Data and Variables

The analyses draw on large-scale survey data collected by Ipsos on behalf of Sport England (2024, 2025). These datasets were chosen because the youth and adult surveys share a parallel structure, with several items identically worded across both instruments. This allows direct comparison of motivational mechanisms across life stages. All motive items are self-reported, single-item measures. Appendix A lists the corresponding survey questions. To maintain comparability and avoid skew from small subgroups, only cisgender adults without disabilities were retained. Ethnicity and gender were included as control variables. Observations with missing data or "I don't know" answers on any used item were likewise excluded. Additional descriptive statistics, including means, medians, standard deviations, and percentages of missing values (excluded from analysis), are provided in Appendix C.

Motivational and behavioural variables:

- Enjoyment – finding exercise satisfying or pleasurable.
- Social – exercising for fun or connection with friends.
- Fitness – exercising to maintain or improve physical health.
- Guilt – exercising out of obligation or self-pressure.
- Opportunity – having access, time, or suitable conditions to exercise.
- Relaxation – exercising to relieve stress or worry.
- Ability – self-perceived competence and confidence in physical activity.
- Importance – recognizing the personal value or significance of physical activity.
- Challenge – persistence and enjoyment in pursuing difficult tasks.
- Minutes – total weekly minutes of moderate-to-vigorous physical activity (see Appendix B for list of activities).

Although this study did not directly measure constructs from SDT, some of the examined motives can be conceptually mapped onto its continuum of motivational regulation. Enjoyment in exercise reflects intrinsic motivation, while exercising to stay fit and healthy, to relax, or because one understands its benefits represent forms of identified regulation, where behaviour is valued and self-endorsed but instrumental. Exercising socially for fun with friends can reflect either intrinsic or identified regulation, depending on whether the enjoyment is derived from the activity or from shared experiences. In contrast, exercising due to guilt exemplifies introjected regulation, reflecting internal pressure and partial internalisation. These mappings should be regarded as conceptual approximations rather than definitive classifications.

Adult Dataset

The adult data derive from the Active Lives Adult Survey (Year 8: 2022–2023), conducted by Ipsos for Sport England with additional support from the Office for Health Improvement and Disparities (OHID). The survey is designed to provide a nationally representative picture of adult participation in sport and physical activity in England.

Sampling was based on the Postcode Address File (PAF), using a random probability design. Up to two adults (aged 16+) per selected household were invited to participate. A push-to-web approach was employed: two initial mailings invited online completion, followed by a third mailing with a paper questionnaire to increase response rates, and a final reminder letter. Data collection occurred from November 2022 to November 2023, with approximately 500 responses targeted per local authority to minimise seasonal and geographic bias.

A total of 173,950 adults completed the survey. Weighting adjustments were applied to correct for differential response probabilities. The questionnaire covered a broad range of topics, including physical activity frequency and duration, sports participation, volunteering, club membership, and motivational factors, along with demographic variables such as age, gender, education, and socio-economic status.

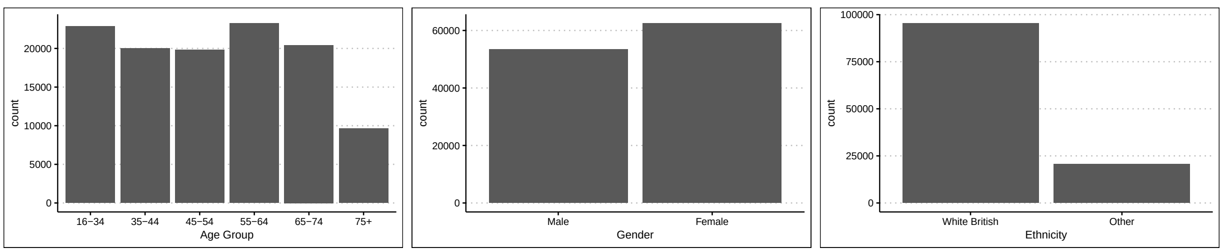


Figure 1: Distribution of age, gender, and ethnicity in adults.

Females comprised 54% of the sample, and White British participants accounted for 82%. The youngest and oldest age groups were collapsed due to small cell sizes at the extremes. Specifically, adults aged 64–75 and 76+ were combined, as preliminary analyses indicated no meaningful differences in their motivational profiles. Collapsing these categories improved model stability without obscuring theoretically relevant distinctions, which are less pronounced in later adulthood. After adjustment, the age distribution remained moderately skewed but acceptable for analysis. Cases with missing values on any motive items were excluded from all models.

Table 1: Proportion of positive responses in adults.

	Proportion
enjoyb	0.3454
socialb	0.1354
fitb	0.4241
guiltb	0.1813
oppb	0.3909
relxb	0.2630

The distributions of positive responses exhibit a left skew, suggesting that participants rarely chose the highest agreement category for most items.

Each item was rated on a five-point Likert scale ranging from 1 (strongly agree) to 5 (strongly disagree). Due to low frequencies in the higher disagreement categories, negative responses of (disagree and strongly disagree) were combined to reduce sparsity and minimize distortion.

For most motive items, the proportion of adults expressing strong positive agreement declines with age. Older adults are less likely than younger adults to strongly endorse beliefs such as feeling capable of engaging in

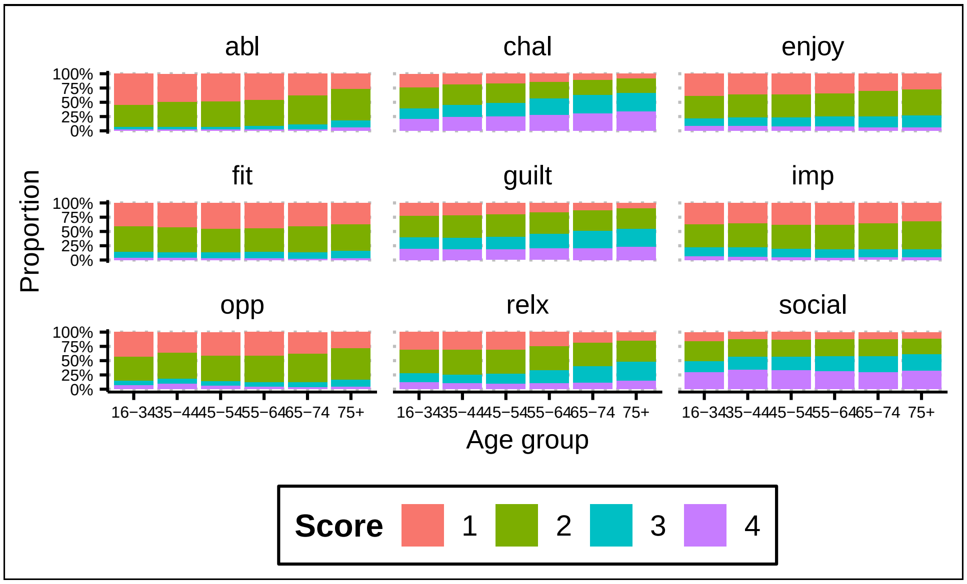


Figure 2: Distribution of adult responses for each motive on the Likert scale.

physical activity, valuing it for the challenge, or pursuing it for enjoyment and fitness. They are also less likely to report strong guilt for not exercising, to perceive sufficient opportunities for activity, or to consider physical activity an important means of relaxation.

Youth Dataset

The youth data come from the Active Lives Children and Young People Survey (Year 6: 2022–2023), conducted by Ipsos on behalf of Sport England, which parallels the adult survey in design and content. It is a large-scale, school-based online survey administered to pupils in Years 1–11, their parents (for Years 1–2 pupils), and teachers. Only pupil responses from year 6-11 (age 11-16) were used in this dissertation. The pupil questionnaire focused on participation in sport and physical activity over the previous week, alongside items on swimming, cycling, volunteering, wellbeing, and attitudes towards physical activity. It also included classification questions such as gender, disability, and long-term health conditions.

The sampling strategy was designed to permit analysis at both national and local authority levels. A stratified three-stage sampling process was used: schools were first sampled from the January 2021 school census, then three year groups were randomly selected within each participating school, and finally, one mixed-ability class was chosen per selected year group. Fieldwork was carried out in three phases aligned with the academic terms (September 2022–July 2023). Pupils typically completed the survey at school under teacher supervision, although in some secondary schools it could also be set as homework. To encourage participation, schools received credits for sports equipment and, if response thresholds were met, school-level feedback reports.

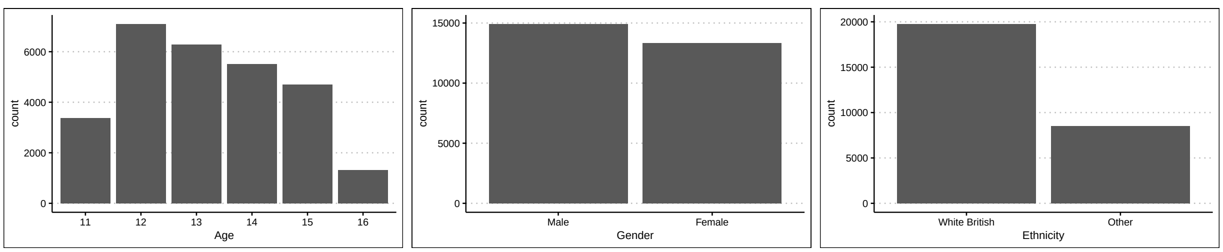


Figure 3: Distribution of age, gender, and ethnicity in youths.

47% of the youth sample are female, and 70% are White British. Most participants are aged 12–15, with only 4.63% aged 16. Although 16-year-olds represent a small proportion of the sample, they were not collapsed with the 15-year-olds. This decision was guided by substantive, rather than purely numerical, considerations: the transition from 15 to 16 marks a distinct developmental and social stage—such as reaching legal thresholds, completing compulsory schooling, and gaining increased autonomy—which may influence physical activity motives. Retaining this distinction allows examination of whether these developmental turning points are reflected in motivational patterns, even within a relatively small subgroup.

Table 2: Proportion of positive responses in youths.

	Proportion
enjoyb	0.5094
socialb	0.2328
fitb	0.4145
guiltb	0.1411
oppb	0.5205
relxb	0.2529

The distributions of positive responses exhibit a left skew, similar to the adults, suggesting that participants rarely chose the highest agreement category across items.

Each item was rated on a four-point Likert scale ranging from 1 (strongly agree) to 4 (strongly disagree). As with the adult data, lower-frequency disagreement categories were collapsed to reduce sparsity. After collapsing, the items are generally balanced, except for social, guilt, and relaxation. Response patterns

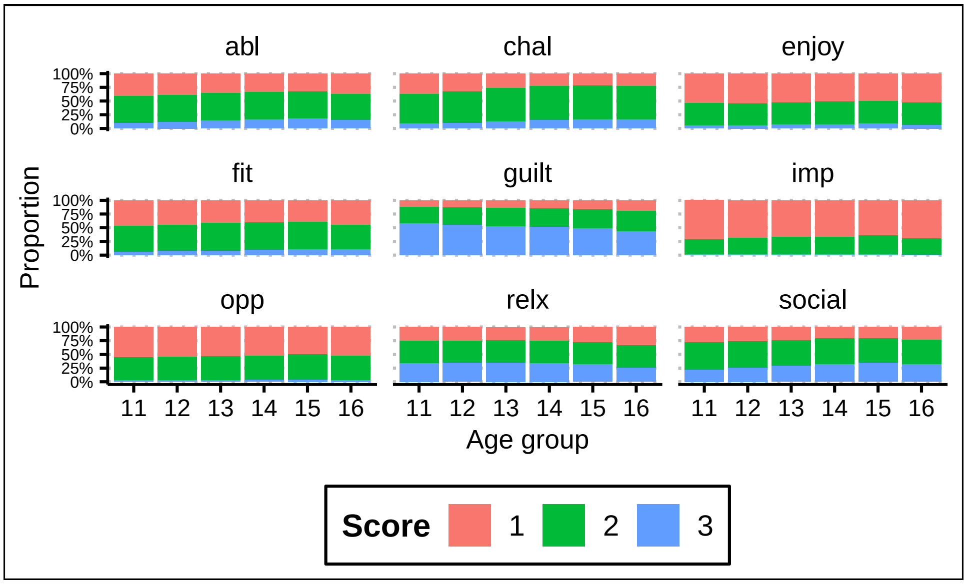


Figure 4: Distribution of youth responses for each motive on the Likert scale.

among youths are less consistent than those observed in adults. With increasing age, youths are less likely to report exercising for challenge or social reasons, while a larger proportion indicate exercising due to guilt or for relaxation. Among the oldest youth group, there is a slight but noticeable increase in the proportion who “strongly agree” that ability and fitness are motivating factors. Across all ages, only a small minority report lacking understanding of the importance of physical activity.

Statistical Analysis

Multigroup structural equation modeling was used to examine whether the strength of associations between motivational items and physical activity differs by age group. Latent class analysis was conducted separately for youth and adult samples to identify distinct motivational profiles within each group. Two motive items (challenge and importance) were excluded from SEM due to non-equivalent wording across the surveys but were retained for LCA. Subsamples used for the two analyses were similar in terms of gender and ethnicity distributions.

Multigroup Structural Equation Modeling (SEM)

Differences in the slopes of motive items were examined while controlling for demographic factors (see Appendix E for model specifications). This approach directly addresses Hypothesis 1 by testing whether the strength of association between each exercise motive and weekly physical activity varies between youths and adults. Specifically, it allows assessment of whether enjoyment, social, and guilt motives exert stronger effects in youths (H1a), fitness and relaxation motives are more influential in adults (H1b), and whether environmental opportunities have comparable effects across age groups (H1c).

To account for differences in Likert scales between adults and youths, all motivation variables were dichotomized into "strongly agree" versus "not strongly agree." Youth participants included only those aged 11 and older who responded to the relevant items. Adults were grouped into age ranges (16–34, 35–44, 45–54, 55–64, 65–74, 75+) because exact ages were unavailable. The youngest and oldest two adult groups were further collapsed to reduce skew and ensure more balanced distributions. A cap of 1,680 minutes per week was applied to reported PA to minimize the influence of extreme values or potential data entry errors. 116,873 adult and 29,798 youth respondents were included.

A freely estimated model was first fitted, followed by a series of constrained models in which individual or all motive pathways were fixed to equality across groups. This stepwise approach allowed assessment of whether the predictive strength of specific motives differed significantly between youths and adults.

Prior to fitting the SEM models, assumptions were assessed. Moderate correlations were observed among the motivational predictors in both youth and adult samples, with most values ranging between 0.2 and 0.5. The highest correlations were between enjoyment and ability in youths ($r = 0.656$) and between enjoyment and perceived importance in adults ($r = 0.674$), slightly exceeding the conventional threshold of $r = 0.6$ for concern about multicollinearity. Standardized residual correlations were also examined to evaluate local fit for both youth and adult SEMs. Most residuals were below 0.35, indicating generally acceptable correspondence between observed and model-implied correlations. The largest residuals occurred among closely related motivational items (enjoyment, fitness, opportunity, and relaxation), with several exceeding 0.4, reflecting misfit due to conceptual overlap and the use of dichotomized indicators. Residuals involving demographics and physical activity minutes were consistently low. These localized discrepancies do not affect the primary purpose of testing whether the strengths of associations between motives and physical activity differ across groups.

Latent Profile Analysis (LCA)

LCA was used to identify distinct motivational profiles within youths and adults, with the original Likert-scale motive items serving as indicators. Ethnicity, gender, and age were included as covariates. Ten random starts were used per class model to ensure solution stability, and 116,018 adult and 28,269 youth respondents were included.

The optimal number of classes was determined based on BIC elbow plots, relative entropy, bootstrap Vuong-Lo-Mendell-Rubin likelihood ratio tests (BLRT), class proportions, and substantive interpretability. Multinomial logistic regression with age as a predictor was then applied, and odds ratios with 95% confidence intervals were calculated by exponentiating the estimated coefficients. This approach directly addresses Hypothesis 2 by testing whether the probability of belonging to lower-agreement profiles increases with age among adults (H2a) and youths (H2b).

Conditional independence among PA-related items was assessed using standardized bivariate chi-square statistics. Extremely sparse cells (<1% of observations) inflated these values, making them unreliable indicators of local dependence. Given that the key motivational items represent conceptually distinct constructs, minor violations are less concerning than for highly overlapping indicators. Model evaluation relied on conventional LCA fit indices, including BIC and entropy, alongside substantive interpretability. These criteria indicated that the identified profiles were robust and meaningful despite the limitations of the conditional independence tests.

Software and Packages

All analyses were conducted in R (version 4.4.3). Multigroup SEM was performed using the lavaan package (Rosseel, 2012). LCA and related statistics were conducted using packages poLCA (Linzer & Lewis, 2011) and poLCAExtra (Choi, 2023).

Results

• Present the results of the analysis. • Try to focus on how the results answer your research questions and hypotheses. • Try to focus on substantive interpretation of the results (and not just if something is significant or not). Are the effects large? Are they substantively important?

Multigroup SEM

Significant age-related differences were observed in the strength of associations between motivational factors and weekly physical activity (PA). Because motive variables were binary, coefficients represent the estimated change in weekly PA minutes associated with strong agreement for each motive.

Table 3: Estimated slopes of each motivational factor in the SEM, with differences calculated as youth minus adult values. All differences were statistically significant ($p < 0.05$).

var	est.youth	est.adult	diff
enjoyb	139.27	115.34	23.93
guiltb	28.74	11.88	16.86
oppb	33.19	96.44	-63.25
fitb	67.36	92.56	-25.20
socialb	32.70	56.63	-23.93
relxb	59.28	43.19	16.09

Enjoyment and guilt motive items both had a stronger effect in youths than in adults, with differences of 24 and 17 minutes, respectively. However, social motive had a larger effect in adults than in youths, with a difference of 24 minutes. These results partially support H1(a) and are somewhat unexpected, as youths were anticipated to place greater importance on the social aspects of physical activity. Fitness was a stronger predictor among adults than among youths, showing a difference of 25 minutes, whereas relaxation was more influential in youths. Thus, H1(b) is only partially supported. This finding is counterintuitive, as one might assume adults would place greater value on stress-relief methods. Environmental opportunity had a stronger effect among adults, with a difference of 63 minutes, contradicting the hypothesis that it would affect both groups similarly. This discrepancy may be due to youths having more consistent access to facilities such as school gyms and playgrounds, while adults are more likely required to pay for private gym memberships.

These findings demonstrate clear age-related shifts in motivational drivers. Youths are more responsive to internalized motives, whereas external factors play a larger role in adults. Notably, the effect of opportunity is far larger than that of any other motive, suggesting that adults' engagement in physical activity is strongly contingent on factors such as access, time, and environmental support. Within the SDT framework, this would suggest that as youths transition to adulthood, intrinsic (enjoyment), identified regulation (relaxation), and introjected regulation (guilt) tend to weaken, while contextual factors (opportunity) become increasingly salient. The social motive may be an exception because it helps fulfill needs that are less satisfied by intrinsic enjoyment in adulthood. Alternatively, it may be interpreted that the determinants of intention appear to shift with age. Applying the TPB, the results imply personal valuation (enjoyment and relaxation) and perceived social expectations (guilt) have a stronger influence on youths and decreases with age. However, despite these patterns, the differences for most motives are weak to moderate in magnitude, suggesting that the overall motivational structure may be largely similar.

LCA

Adults

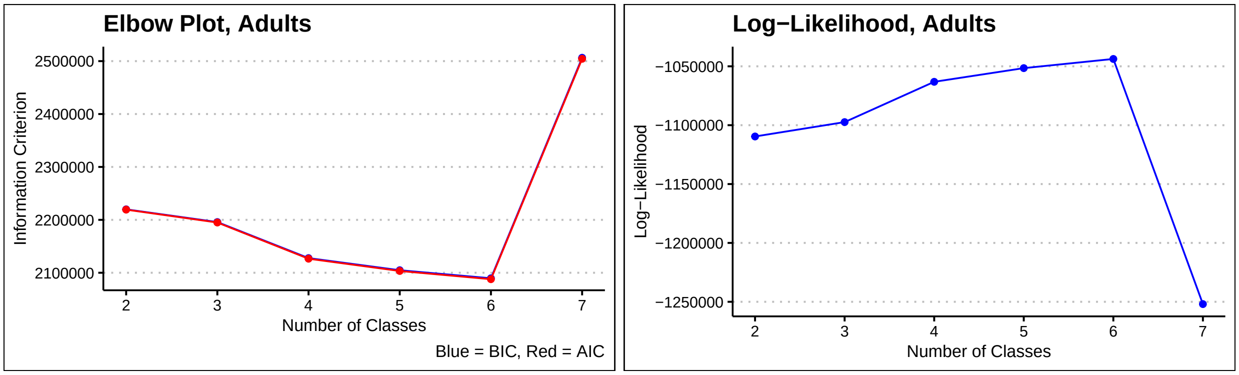


Figure 5: Elbow plot showing AIC and BIC values, and maximum likelihood plot, across different numbers of latent classes in adults.

Latent class models ranging from 3 to 6 classes all demonstrated relatively high likelihoods, low AIC and BIC values, and reasonable average posterior entropy per class. From the elbow plot, the 4-class model appeared to show diminishing returns, suggesting that adding more than three classes did not provide a substantial improvement in model fit. However, the 3-class model displayed significantly higher relative entropy, indicating a more nuanced classification of individuals. While they both have good entropy values at 0.7998 and 0.7473, the 4-class solution resulted in two groups with nearly identical endorsement patterns, effectively splitting the moderate group without introducing meaningful differentiation. Hence, the 3-class model is favored for its balance between simplicity and the ability to distinguish meaningful motivational profiles.

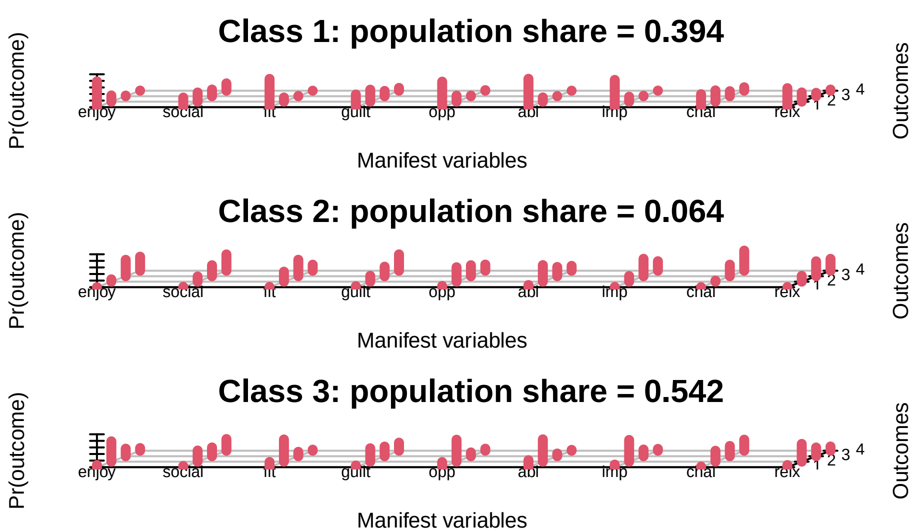


Figure 6: Frequency of adult responses for each motive by class membership.

Class 1 Class 1 represents adults who consistently report strong agreement across a broad range of motivations. Members show high probabilities of strongly agreeing with motives related to enjoyment, fitness, ability, opportunity, and importance. They also moderately endorse social, challenge, and guilt motives, and express relatively high agreement with relaxation. This group is labeled the High Engagement class.

Class 2 Class 2 is characterized by very low probabilities of strongly agreeing with enjoyment and ability, and by a higher prevalence of neutral or negative responses across most other items. Members tend to express the least favorable attitudes toward physical activity. Labelled the Low Engagement class, it represents a relatively small proportion of the sample (~6%). Despite its size, this class aligns with the raw data, where very few respondents selected negative responses.

Class 3 Class 3 exhibits a mixed attitude toward various motives, with moderate positive endorsements of enjoyment, fitness, opportunity, ability, and importance. It represents adults who show more ambivalent responses overall. This group is labeled the Mixed Motivation class.

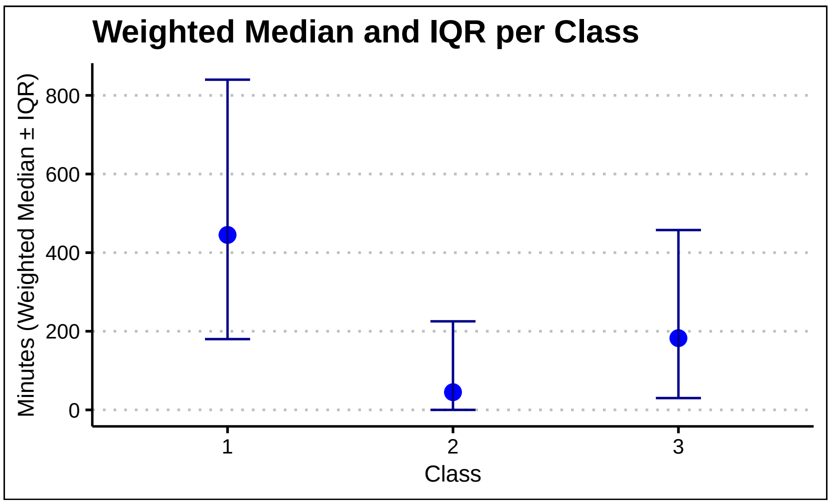


Figure 7: Weighted median and interquartile range of minutes exercised per week for adults by class.

Analysis of weekly minutes of physical activity across the adult latent classes highlights substantial differences in exercise behaviour. The High Engagement class exhibits the highest levels, with a weighted median of 445 minutes per week and a wide interquartile range of 180 to 840 minutes, indicating considerable variability even among this highly active group. The Mixed Motivation class reports intermediate activity, with a median of 182.5 minutes per week and an IQR of 30 to 457.5 minutes, reflecting both moderate overall engagement and substantial individual differences. In contrast, the Low Engagement class shows markedly lower activity, with a median of only 45 minutes per week and an IQR from 0 to 225.25 minutes, highlighting that while most members are minimally active, some still achieve higher levels. Overall, the broad IQRs across all classes indicate that even within latent classes defined by motivation, actual exercise behaviour varies considerably.

The distribution of age groups across the three latent classes highlights notable differences in motivational profiles. The High Engagement class is consistently the second most populous across age groups, though its representation declines gradually with increasing age. The Low Engagement class remains the smallest in all age groups, representing a relatively rare subgroup with low endorsement of motives, and its relative size is largely stable across ages. In contrast, the Mixed Motivation class contains the largest number of adults in every age group, with membership increasing steadily as age rises, suggesting that some individuals may shift from high engagement to mixed motivation over time.

Multinomial logistic regression examined the association between age and motivation profile, with the High Engagement class as reference. Examination of the odds of latent class membership across adult age groups, using the youngest group (16–34 years) as the reference, reveals clear age-related patterns. Adults in the

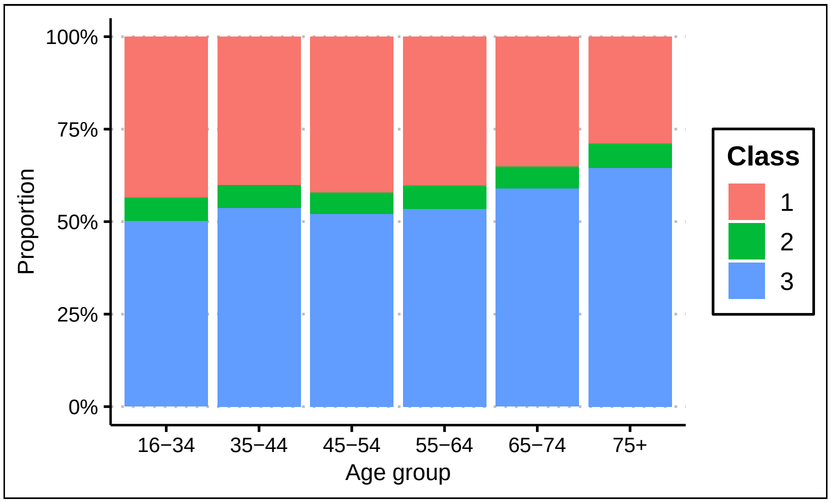


Figure 8: Proportion of adults in each class across age groups.

Table 4: Odds ratios for adult class membership across age groups, with the youngest group (16–34 years) as the reference.

	(Intercept)	age2	age3	age4	age5	age6
2	0.149	1.023	0.9118	1.046	1.143	1.515
3	1.153	1.159	1.0696	1.149	1.453	1.930

youngest age group are over 6.6 times more likely to belong to the High Engagement class than to the Low Engagement class. Conversely, a slightly higher proportion of young adults belong to the Mixed Motivation class, which may partly reflect the overall larger size of this class. For the Low Engagement class, older age groups generally show modestly higher odds of membership compared with the reference, though the differences for age groups 35–44 and 55–64 are not statistically significant. The highest odds are observed in the oldest age group (75+), suggesting that adults in this group are 1.5 times more likely to belong to the Low Engagement class than younger adults. In the Mixed Motivation class, the odds of membership increase consistently with age, with adults aged 65–74 being 1.45 times, and those 75+ being 1.93 times more likely than 16–34-year-olds to belong to this class rather than High Engagement.

As adults age, external motivations, such as maintaining health, improving fitness, or fulfilling social obligations, may take precedence over purely intrinsic factors. This gradual shift from intrinsic to extrinsic regulation is partially reflected in the Mixed Motivation class, which shows a combination of both internally driven motives (e.g., enjoyment, personal challenge) and externally oriented motives (e.g., fitness, opportunity, social engagement). In contrast, the Low Engagement class, characterized by low motivation across both intrinsic and extrinsic domains and correspondingly low physical activity, becomes increasingly prominent among older adults, suggesting that some individuals may experience an overall decline in motivational drivers with age. This class potentially reflects amotivation in SDT, where individuals lack both intrinsic and extrinsic reasons to engage in physical activity. From a TPB perspective, this trend may be explained by age-related changes in the determinants of intention. Older adults may experience lower PBC due to physical limitations, reduced access to exercise opportunities, or decreased social support. Additionally, normative beliefs and subjective norms may weaken as individuals move beyond life stages where social expectations strongly influence behaviour. Consequently, behavioural intention lowers, which in turn contributes to lower engagement in physical activity. These theoretical considerations help explain why older adults are significantly more likely to be classified in the Low Engagement group and underscore the substantive decline in overall motivation.

Youths

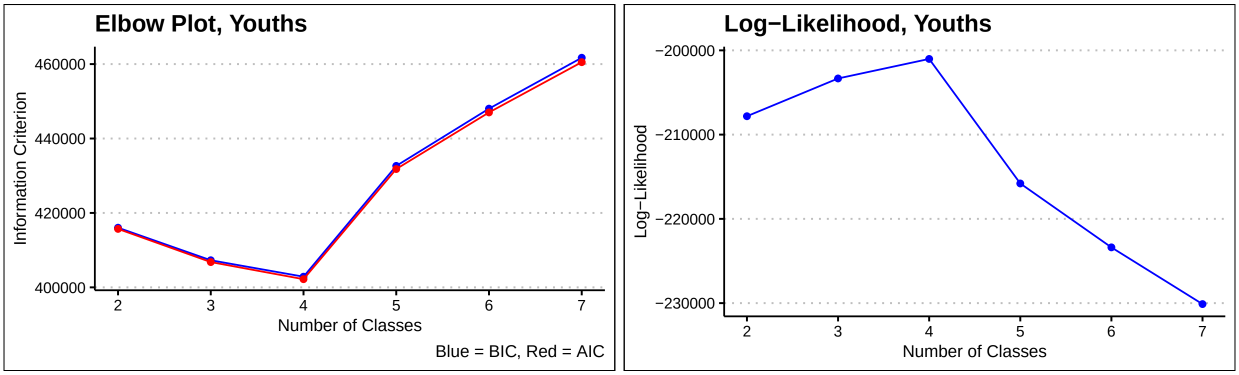


Figure 9: Elbow plot showing AIC and BIC values, and maximum likelihood plot, across different numbers of latent classes in youths.

The AIC/BIC plot did not show the typical elbow shape, as adding more classes beyond four actually resulted in a decrease in model fit. This could be due to the log-likelihood not increasing significantly with the addition of more classes, causing BIC's penalty for model complexity to outweigh any improvement in fit. Nevertheless, both the 3-class and 4-class solutions resulted in the most substantial reductions in BIC. The Bootstrap Likelihood Ratio Test (BLRT) preferred the 4-class model. However, when considering relative entropy values, which were 0.7998 for the 3-class model and 0.7473 for the 4-class model, the 3-class solution provided better separation between classes. The likelihood values for the 3-class and 4-class models were similar, but the average posterior probabilities were higher in the 3-class model, with all classes exhibiting a posterior probability greater than 0.80. Additionally, the 4-class model resulted in two very similar classes, suggesting that the additional class did not add meaningful differentiation. Given these considerations, the 3-class model was selected for its better separation and more parsimonious structure.

Class 1 Class 1 represents youths who consistently report strong agreement across a broad range of motivations. Members show high probabilities of strongly agreeing with motives related to enjoyment, fitness, opportunity, importance, and ability. They also moderately endorse social, challenge, and relaxation motives, and express relatively high agreement with guilt. This group is characterized by consistently positive attitudes toward a wide range of motives. This class is labeled the High Engagement class.

Class 2 Class 2 is characterized by very low probabilities of strongly agreeing with any motives, and by a higher prevalence of neutral or negative responses across most other items. Members tend to express the least favorable attitudes toward physical activity. Labeled the Low Engagement class, this group represents a relatively small proportion of the sample, aligning with the raw data in which very few respondents selected negative responses.

Class 3 Class 3 exhibits a mixed attitude toward various motives, with moderate positive endorsements of enjoyment, fitness, opportunity, ability, and importance. Disagreement is relatively uncommon, but strong agreement is also less prevalent than in the High Engagement class. This group falls between the other two, representing generally positive but not strongly emphatic motivation toward physical activity. This class is labeled the Moderate Engagement class.

Analysis of weekly minutes of physical activity across the youth latent classes reveals meaningful differences in exercise behaviour. The High Engagement class reports the highest levels, with a weighted median of 405 minutes per week and an interquartile range of 185 to 745 minutes, indicating substantial variability even among the most motivated youths. The Mixed Motivation class shows intermediate activity, with a median of 235 minutes per week and an IQR from 90 to 455 minutes, reflecting moderate engagement with considerable

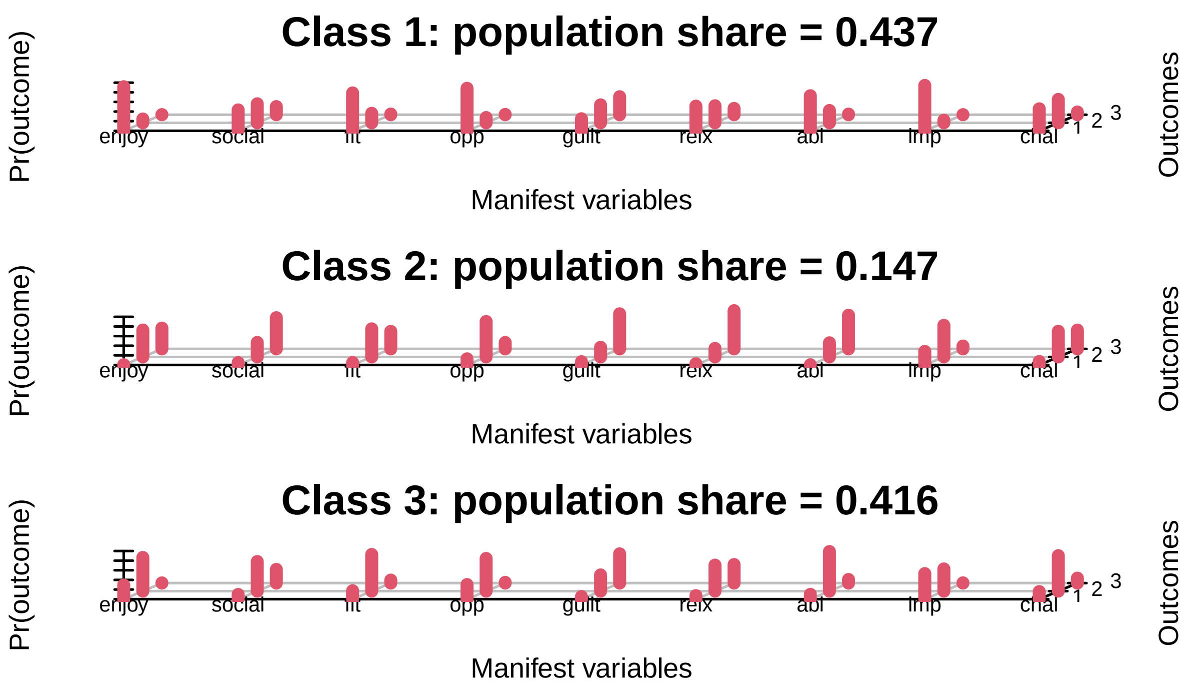


Figure 10: Frequency of adult responses for each motive by class membership.

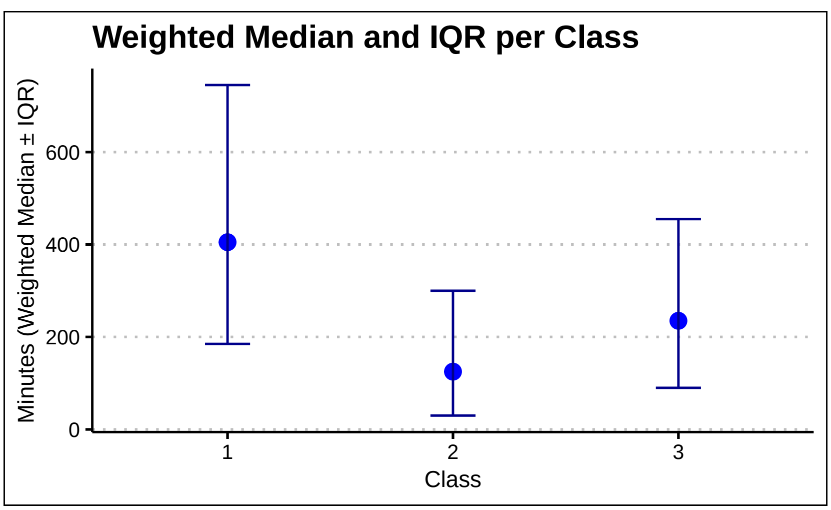


Figure 11: Weighted median and interquartile range of minutes exercised per week for youths by class.

individual differences. The Low Engagement class exhibits the lowest activity, with a median of 125 minutes per week and an interquartile range of 30 to 300 minutes, suggesting that while most members are less active, some still achieve moderate levels. These patterns imply that, similar to adults, class membership captures meaningful distinctions in motivation that are associated with actual physical activity.

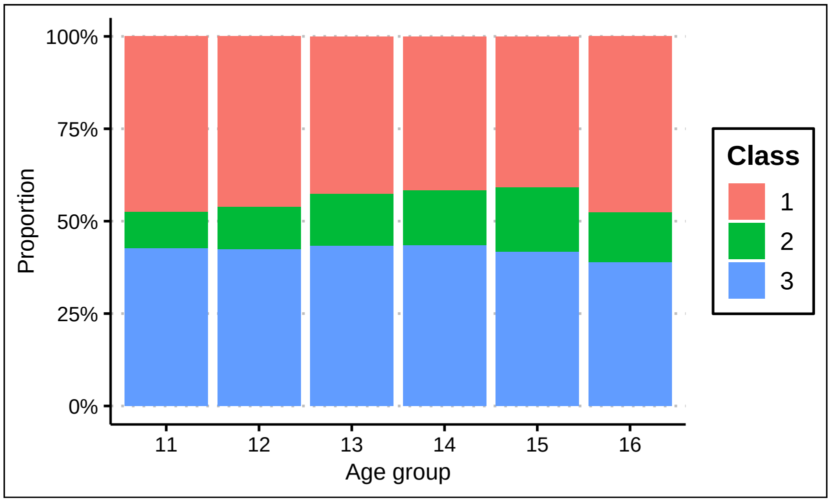


Figure 12: Proportion of youths in each class by age.

The distribution of age groups across the three latent classes highlights notable differences in motivational profiles among youths. The High Engagement and Mixed Motivation classes are roughly similar in size, with the High Engagement class generally decreasing across age groups but showing a sudden increase at age 16. The Low Engagement class is smaller than the other two but not as rare as in the adult sample; it increases steadily with age, with a slight dip at age 16. These patterns suggest that while high engagement may decline during adolescence, a substantial portion of youths maintain strong or mixed motivation, and low engagement gradually becomes more common over time. The sudden increase in High Engagement at age 16 indicates that some youths may experience a late boost in motivation during this stage of adolescence.

Table 5: Odds ratios for youth class membership across ages, with 11-year-olds as the reference.

	(Intercept)	age2	age3	age4	age5	age6
2	0.2086	1.197	1.586	1.701	2.036	1.3617
3	0.8991	1.021	1.129	1.158	1.134	0.9087

Examination of the odds of latent class membership across youth age groups, using 11-year-olds as the reference, reveals distinct developmental patterns. At age 11, youths are approximately 5 times less likely to belong to the Low Engagement class compared with High Engagement, whereas they are about equal in odds to belong to the Mixed Motivation class. For the Low Engagement class, the odds of membership increase steadily with age, with 12-year-olds about 1.2 times more likely, 13-year-olds 1.6 times more likely, 14-year-olds 1.7 times more likely, and 15-year-olds 2 times more likely than 11-year-olds to belong to this class, before slightly declining at age 16 (1.4 times more likely). In the Mixed Motivation class, the odds of membership increase modestly from ages 12–15, ranging from 1.0 to 1.2 times more likely than 11-year-olds, before declining slightly at age 16 (0.9 times as likely). These patterns indicate that as youths age, they increasingly shift from High Engagement toward Low Engagement or Mixed Motivation, with a subtle rise in motivation at age 16 suggesting that some youths regain or consolidate engagement in physical activity.

The trends indicate a gradual decline in motivation throughout adolescence, with older youths increasingly represented in classes showing moderate or lower endorsement of motivational items, consistent with H2(b). Between ages 12 and 15, there is a notable shift toward mixed motivation and greater reliance on external regulation. This pattern may reflect a reduction in perceived autonomy as adolescents encounter heightened external pressures, such as academic demands and peer expectations. As autonomy decreases, youths may depend more on external motivators, such as social influence or structured opportunities, to maintain engagement in physical activity. Interestingly, the sudden surge in membership in the High Motivation class at age 16 suggests developmental and social factors unique to this stage. At 16, adolescents gain more control over how they allocate their time, alongside legal permissions that expand opportunities to engage in activities outside of school. This increase in autonomy likely enhances intrinsic motivation, particularly for activities that are personally enjoyable or socially rewarding. Social considerations, including peer influence and preparation for post-compulsory schooling or exams, may further reinforce participation in structured physical activity, increasing its perceived relevance. From a TPB perspective, this may reflect higher perceived behavioural control and stronger alignment between attitudes and intentions, supporting the sudden spike in high-motivation membership.

Conclusion

This study examined how perceived exercise motives influence physical activity (PA) across developmental stages and how age shapes dominant motives within youth and adult groups. Specifically, it addressed the research questions: (1) Do perceived exercise motives influence PA differently in youths and adults? and (2) How do age differences shape dominant exercise motives within youth and adult groups? The findings provide some support for the proposed hypotheses. Results indicated that exercise motives do differ in their influence on PA across age groups, generally supporting Hypothesis 1. However, the patterns for social and relaxation motives did not align with predictions: social motives were stronger in adults rather than youths, and relaxation motives were stronger in youths rather than adults, meaning H1(a) and H1(b) are only partially supported. Hypothesis 2 was largely supported. Distinct motivational profiles were identified within both youths and adults. Consistent with H2(a), motivation among adults gradually declined with age, with the oldest adults exhibiting the steepest drop to low motivation. H2(b) was only partially supported, as a similar gradual decline in high motivation class membership was observed among youths, but a sharp increase occurred in the oldest youth group.

The observed discrepancy in the significance of the social motive between adults and youths, which diverges from the hypothesised pattern in H1(a), may be attributed to several methodological and conceptual factors. Variations in survey question wording could influence how respondents interpret and respond to items assessing social motives. For instance, Geller (2018) defines social motives as the extrinsic drive to socially interact and meet new people during physical activities, emphasizing the external nature of this motivation. In contrast, Bragg (2018) categorizes social motive as "social influence", encompassing the impact of friends, parents, family members, coaches, and health professionals on an individual's physical activity choices. These differing definitions may lead to variations in how social motives are perceived and reported across studies. In addition, the conflation of various forms of physical activity in survey instruments can obscure the specific motives associated with different activities. For example, Vuckovic (2024) found that social motives were less influential in fitness activities but more significant in sport participation. However, in surveys that combines all types of physical activity without distinguishing between them, such as the one used for this dissertation, the unique impact of social motives on each activity type may be masked.

The prominence of relaxation as a motive in youths, which diverges from the hypothesised pattern in H1(b), may be explained by several developmental and contextual factors. Unsurprisingly, Ashfold (1993) found that among adolescents aged 16 and older, achieving relaxation was one of the most commonly reported motives for participation, highlighting its general importance in this age group. Physical activity has also been shown to reduce stress and enhance performance-related outcomes: Teuber (2024) reported that in university students, engagement in physical activity not only reduced stress but also enhanced perceived academic performance. While this sample is older than the youths in the present study, the academic pressure context is analogous. Relief of stress has also been identified as a key determinant of fun in youth sports, promoting sustained engagement (Visek, 2015). Notably, Do et al. (year) found that elevated momentary stress predicts lower subsequent PA. Since the present study does not assess causality, there is the possibility that relaxation motives drive higher activity rather than the reverse. More broadly, personal experiences of relaxation and stress relief appear to foster adolescents' understanding of the benefits of exercise, which may in turn drive PA engagement (Kostamo, 2019). Moreover, although gender differences in relaxation motives have been reported where relaxation serves as a more prominent motive for females (Kondric, 2013), the fairly balanced gender distribution in our youth sample suggests this factor does not meaningfully influence the overall pattern observed.

Contrary to H1(c), opportunity appears to play a more significant role in determining physical activity (PA) minutes among adults than youths, possibly due to contextual and structural constraints. Rising opportunity costs associated with PA participation can limit the frequency of engagement, particularly among highly educated adults who are aware of the health benefits of PA but often hold sedentary (Brown & Roberts, 2011). In addition, women often face fewer chances to engage in PA than males, particularly in cultural contexts where they are primarily responsible for household caretaking, restricting access to outdoor or leisure-based activity (Jalaluddin, 2024).

The sudden increase in motivation for PA around age 16 may reflect several developmental and social factors, although direct empirical evidence is limited. Adolescents gain greater autonomy over how they allocate their time, including extracurricular and leisure activities, enhancing intrinsic motivation. Legal and social transitions, such as eligibility for independent travel or part-time work, expand opportunities for engagement. Cognitive development supports a more sophisticated understanding of long-term health benefits, personal goals, and social identity, allowing adolescents to internalize the value of PA. Social influences, including peer norms and preparation for post-compulsory education, further reinforce participation. From a TPB perspective, increased perceived behavioural control and more salient social norms help adolescents translate intentions into action. Taken together, these factors provide a plausible explanation for the sharp rise, though further research is required to confirm these hypotheses.

Policy Implications

For adolescents, policies should prioritise autonomy and intrinsic motivation. Choice in activity type, intensity, and scheduling can sustain engagement. Fun, low-pressure activities are recommended since relaxation and stress relief are key motives. Social interaction remains important but should focus on cooperative play without performance pressure. Around age 16, adolescents gain more control over their schedules. Policies should support this by providing access and guidance for self-directed activity to help translate newfound autonomy into sustained participation.

For adults, structural and social opportunities strongly influence PA. Workplace initiatives, flexible scheduling, and accessible community facilities can reduce the opportunity cost of PA for those balancing work, family, and other responsibilities. As intrinsic motives like enjoyment may decline with age, social motives can sustain engagement through extrinsic reinforcement. Policies should also address differential access, particularly for women with domestic responsibilities, by providing inclusive, low-barrier options.

In older adulthood, declines in intrinsic motivation and physical capacity necessitate targeted environmental and social support. Policies should prioritise safe, accessible spaces for light-to-moderate activity and structured programs that provide social interaction alongside exercise. Enhancing perceived behavioural control through instruction, adapted exercises, and social encouragement can support continued participation. Community centres, walking groups, and low-impact classes that emphasise wellbeing, socialisation, and structured opportunity can mitigate age-related declines in PA engagement.

The developmental patterns observed suggest that motivation toward PA is dynamic across the lifespan. Future research should examine longitudinal trajectories of motivation and investigate how interventions can effectively support intrinsic and extrinsic regulation across different age groups.

Limitations

Several limitations may affect the interpretation of these results. All data were self-reported and therefore susceptible to recall errors, comprehension difficulties, and social desirability bias, especially among students responding under teacher supervision. The adult sample, collected primarily online, may underrepresent individuals with limited digital literacy or internet access, such as older adults or lower-income households. Allowing up to two respondents per household could have increased intra-household similarity, and minor differences between online and paper formats may have affected reported PA or demographic details. To ensure comparability, only motive items with identical or near-identical wording were retained, possibly omitting relevant constructs. PA measures were highly skewed, though the use of medians and response collapsing mitigated non-normality. Analyses focused on moderate-to-vigorous PA, which may underestimate meaningful engagement among older adults who benefit from light activity. Finally, demographic factors such as socioeconomic status, weight, education, relationship status were not considered, and the cross-sectional design prevents causal inference about developmental changes in motivation or behaviour.

References

Guan, J., Xiang, P., Land, W., & Hamilton, X. D. (2023). Age and Gender Differences in Achievement Goal Orientations in Relation to Physical Activity. Perceptual and motor skills, 130(1), 80–93. https://doi.org/10.1177/00315125221139000

Jalaluddin, Nawab, T., Khalique, N., & Ahmad, A. (2024). Physical Inactivity and its Sociodemographic Determinants among Adults: A Community-Based Study. Indian journal of community medicine : official publication of Indian Association of Preventive & Social Medicine, 49(6), 849–854. https://doi.org/10.4103/ijcm.ijcm_130_23

Brown, H., & Roberts, J. (2011). Exercising choice: the economic determinants of physical activity behaviour of an employed population. Social science & medicine (1982), 73(3), 383–390. https://doi.org/10.1016/j.socscimed.2011.06.001

Kostamo, K., Vesala, K. M., & Hankonen, N. (2019). What triggers changes in adolescents' physical activity? Analysis of critical incidents during childhood and youth in student writings. Psychology of Sport and Exercise, 45, Article 101564. https://doi.org/10.1016/j.psychsport.2019.101564

Visek, A. J., Achrati, S. M., Mannix, H., McDonnell, K., Harris, B. S., & DiPietro, L. (2015). The fun integration theory: toward sustaining children and adolescents sport participation. Journal of physical activity & health, 12(3), 424–433. https://doi.org/10.1123/jpah.2013-0180

Do, B., Mason, T. B., Yi, L., Yang, C. H., & Dunton, G. F. (2021). Momentary associations between stress and physical activity among children using ecological momentary assessment. Psychology of sport and exercise, 55, 101935. https://doi.org/10.1016/j.psychsport.2021.101935

Teuber, M., Leyhr, D. & Sudeck, G. Physical activity improves stress load, recovery, and academic performance-related parameters among university students: a longitudinal study on daily level. BMC Public Health 24, 598 (2024). https://doi.org/10.1186/

Ashford B, Biddle S, Goudas M. Participation in community sports centres: motives and predictors of enjoyment. J Sports Sci. 1993 Jun;11(3):249-56. doi: 10.1080/02640419308729992. PMID: 8336357.

Bragg MA, Tucker CM, Kaye LB, Desmond F. Motivators of and Barriers to Engaging in Physical Activity: Perspectives of Low-Income Culturally Diverse Adolescents and Adults. Am J Health Educ. 2009;40(3):146-154. doi: 10.1080/19325037.2009.10599089. Epub 2009 Jan 23. PMID: 29527247; PMCID: PMC5844488.

Zhang, C., Tang, L. & Liu, Z. How social media usage affects psychological and subjective well-being: testing a moderated mediation model. BMC Psychol 11, 286 (2023). https://doi.org/10.1186/s40359-023-01311-2

Vallerand, R. J. (1997). Toward a hierarchical model of intrinsic and extrinsic motivation. In M. P. Zanna (Ed.), Advances in experimental social psychology, Vol. 29, pp. 271–360). Academic Press. https://doi.org/10.1016/S0065-2601(08)60019-2

Ajzen, I. (2020). The theory of planned behavior: Frequently asked questions. Human Behavior and Emerging Technologies, 2(4), 314–324. https://doi.org/10.1002/hbe2.195

Trigueros R, Aguilar-Parra JM, López-Liria R, Rocamora P. The Dark Side of the Self-Determination Theory and Its Influence on the Emotional and Cognitive Processes of Students in Physical Education. Int J Environ Res Public Health. 2019 Nov 12;16(22):4444. doi: 10.3390/ijerph16224444. PMID: 31726790; PMCID: PMC6888335.

Brooks JM, Iwanaga K, Chiu CY, Cotton BP, Deiches J, Morrison B, Moser E, Chan F. Relationships between self-determination theory and theory of planned behavior applied to physical activity and exercise behavior in chronic pain. Psychol Health Med. 2017 Aug;22(7):814-822. doi: 10.1080/13548506.2017.1282161. Epub 2017 Jan 22. PMID: 28111983; PMCID: PMC6013835.

World Health Organization. (2024, June 26). Nearly 1.8 billion adults at risk of disease from not doing enough physical activity. https://www.who.int/news/item/26-06-2024-nearly-1.8-billion-adults-at-risk-of-disease-from-not-doing-enough-physical-activity

Sport England. (2024). Active Lives Children and Young People Survey, 2022-2023. [data collection]. UK Data Service. SN: 9286, DOI: http://doi.org/10.5255/UKDA-SN-9286-1

Sport England, Ipsos. (2025). Active Lives Adults Survey, 2022-2023. [data collection]. 2nd Edition. UK Data Service. SN: 9288, DOI: http://doi.org/10.5255/UKDA-SN-9288-2

Vuckovic, V., & Duric, S. (2024). Motivational variations in fitness: a population study of exercise modalities, gender and relationship status. Frontiers in psychology, 15, 1377947. https://doi.org/10.3389/fpsyg.2024.1377947

Ostendorf, D.M., Schmiege, S.J., Conroy, D.E. et al. Motivational profiles and change in physical activity during a weight loss intervention: a secondary data analysis. Int J Behav Nutr Phys Act 18, 158 (2021). https://doi.org/10.1186/s12966-021-01225-5

Moreno-Murcia, J. A., Cervelló Gimeno, E., Hernández, E. H., Pedreño, N. B., & Rodríguez Marín, J. J. (2013). Motivational profiles in physical education and their relation to the theory of planned behavior. Journal of sports science & medicine, 12(3), 551–558.

Nuss, K., Sui, W., Rhodes, R., & Liu, S. (2023). Motivational Profiles and Associations With Physical Activity Before, During, and After the COVID-19 Pandemic: Retrospective Study. JMIR formative research, 7, e43411. https://doi.org/10.2196/43411

Ajzen, Icek (1991). “The theory of planned behavior”. Organizational Behavior and Human Decision Processes. 50 (2): 179–211. doi:10.1016/0749-5978(91)90020-T. hdl:11323/1038. S2CID 260959149.

Dishman, R. K., McIver, K. L., Dowda, M., & Pate, R. R. (2018). Declining Physical Activity and Motivation from Middle School to High School. Medicine and science in sports and exercise, 50(6), 1206–1215. https://doi.org/10.1249/MSS.0000000000001542

Varma, V. R., Dey, D., Leroux, A., Di, J., Urbanek, J., Xiao, L., & Zipunnikov, V. (2017). Re-evaluating the effect of age on physical activity over the lifespan. Preventive medicine, 101, 102–108. https://doi.org/10.1016/j.ypmed.2017.05.030

Salvy, S. J., Roemmich, J. N., Bowker, J. C., Romero, N. D., Stadler, P. J., & Epstein, L. H. (2009). Effect of peers and friends on youth physical activity and motivation to be physically active. Journal of pediatric psychology, 34(2), 217–225. https://doi.org/10.1093/jpepsy/jsn071

Biddle, Stuart J. H. , Atkin, Andrew J. , Cavill, Nick and Foster, Charlie(2011) ‘Correlates of physical activity in youth: a review of quantitative systematic reviews’, International Review of Sport and Exercise Psychology, 4:1, 25 — 49. URL:http://dx.doi.org/10.1080/1750984X.2010.548528

Shao, T., & Zhou, X. (2023). Correlates of physical activity habits in adolescents: A systematic review. Frontiers in physiology, 14, 1131195. https://doi.org/10.3389/fphys.2023.1131195

Choi, J., Lee, M., Lee, Jk. et al. Correlates associated with participation in physical activity among adults: a systematic review of reviews and update. BMC Public Health 17, 356 (2017). https://doi.org/10.1186/s12889-017-4255-2

Alixe H M Kilgour, Matthew Rutherford, Joanna Higson, Samantha J Meredith, Jessica McNiff, Stephanie Mitchell, Anusan Wijayendran, Stephen E R Lim, Susan D Shenkin, Barriers and motivators to undertaking physical activity in adults over 70—a systematic review of the quantitative literature, Age and Ageing, Volume 53, Issue 4, April 2024, afae080, https://doi.org/10.1093/ageing/afae080

Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet (London, England). 2012, 380(9838):219–229.

Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U. Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet (London, England). 2012, 380(9838):247–257.

Tapia-Serrano, M. Á., López-Gajardo, M. Á., Sánchez-Miguel, P. A., Llanos-Muñoz, R., & Burgueño, R. (2024). Analysis of motivational profiles of physical activity behavior in primary school students: A self-determination theory-based perspective. Personality and Individual Differences, 231, 112837. https://doi.org/10.1016/j.paid.2024.112837

Sebire, S.J., Jago, R., Fox, K.R. et al. Testing a self-determination theory model of children's physical activity motivation: a cross-sectional study. Int J Behav Nutr Phys Act 10, 111 (2013). https://doi.org/10.1186/1479-5868-10-111

Heredia-León, D. A., Valero-Valenzuela, A., Gómez-Mármol, A., & Manzano-Sánchez, D. (2023). Motivational Profiles in Physical Education: Differences at the Psychosocial, Gender, Age and Extracurricular Sports Practice Levels. Children (Basel, Switzerland), 10(1), 112. https://doi.org/10.3390/children10010112

Geller, K., Renneke, K., Custer, S., & Tigue, G. (2018). Intrinsic and Extrinsic Motives Support Adults' Regular Physical Activity Maintenance. Sports medicine international open, 2(3), E62–E66. https://doi.org/10.1055/a-0620-9137

Brunet, J., & Sabiston, C. M. (2011). Exploring motivation for physical activity across the adult lifespan. Psychology of Sport and Exercise, 12(2), 99–105. https://doi.org/10.1016/j.psychsport.2010.09.006

Oyibo, K., Adaji, I., & Vassileva, J. (2018). Social cognitive determinants of exercise behavior in the context of behavior modeling: a mixed method approach. Digital health, 4, 2055207618811555. https://doi.org/10.1177/2055207618811555

Netz, Yael & Raviv, Shulamith. (2004). Age Differences in Motivational Orientation Toward Physical Activity: An Application of Social—Cognitive Theory. The Journal of psychology. 138. 35-48. 10.3200/JRLP.138.1.35-48.

Beauchamp, M. R., Crawford, K. L., & Jackson, B. (2019). Social cognitive theory and physical activity: Mechanisms of behavior change, critique, and legacy. Psychology of Sport and Exercise, 42, 110–117. https://doi.org/10.1016/j.psychsport.2018.11.009

de Maio Nascimento, M., Gouveia, É. R., Gouveia, B. R., Marques, A., França, C., Campos, P., Martins, F., García-Mayor, J., & Ihle, A. (2023). Differential Patterns in Motivations for Practicing Sport and Their Effects on Physical Activity Engagement across the Lifespan. Healthcare (Basel, Switzerland), 11(2), 274. https://doi.org/10.3390/healthcare11020274

National, regional, and global trends in insufficient physical activity among adults from 2000 to 2022: a pooled analysis of 507 population-based surveys with 5 · 7 million participants. Strain, TessaAbdul Raheem, Raheema et al. The Lancet Global Health, Volume 12, Issue 8, e1232 - e1243

Neipp, Mª & Quiles, María & Leon, Eva & Rodríguez-Marín, Jesús. (2013). Theory of Planned Behavior and physical exercise: Differences between people who do regular physical exercise and those who do not. Wulfenia. 20. 324-335.

Wang, L., & Wang, L. (2015). Using Theory of Planned Behavior to Predict the Physical Activity of Children: Probing Gender Differences. BioMed research international, 2015, 536904. https://doi.org/10.1155/2015/536904

Appendix A - Survey Questions

Adults

Table 6: Adult survey questions.

Variable	Origianl Variable Name	Survey Question
enjoy	Motiva_POP	Motivation for sport/exercise: I find sport/exercise enjoyable and satisfying.
social	motivex2c	I exercise socially for fun with friends.
fit	motivex2a	I exercise to stay fit and healthy.
opp	READYOP1_POP	Readiness for activity: Opportunity,
guilt	motivc_POP	Motivation for sport/exercise: I feel guilty when I don't do sport/exercise.
imp	motivb_POP	Motivation for sport/exercise: It's important to me to do sport/exercise regularly.
chal	motivex2d	I exercise to challenge myself (either against myself or others).
abil	READYAB1_POP	Readiness for activity: Ability.
relx	motivex2b	I exercise to help me relax and worry less about things.

Youths

Table 7: Youth survey questions.

Variable	Origianl Variable Name	Survey Question
enjoy	PL_Enjoy_bc_ans	I enjoy taking part in exercise and sports.
social	MO_Fun_c	I exercise socially for fun with friends.
fit	MO_Fit_c	I exercise to stay fit and healthy.
opp	MO_Opp_c	I feel that I have the opportunity to be physically active.
guilt	MO_Guilt_c	I feel guilty when I don't exercise.
imp	PL_GdMe_bc_ans	I understand why exercise and sports are good for me.
chal	Try_bc	If I find something difficult, I keep trying until I can do it.
abil	PL_Conf_bc_ans	I feel confident when I exercise and play sports.
relx	MO_Relax_c	I exercise to help me relax and worry less about things .

Appendix B - Exercise Types

Adults

The total minutes of exercise in this dissertation are calculated as the sum of vigorous (original variable: DUR_HVY_CAPPED_SPORTCOUNT_A01) and moderate plus (original variable: DUR_MOD_CAPPED_SPORTCOUNT_A01) activities.

Vigorous Exercises

Definition Activity capped: Moderate intensity minutes per week: Sport (count definition), capped at 1680 mins/wk.

- 11 a-side football
- 13 a-side rugby league
- 15 a-side rugby union
- Bootcamp (e.g. drill sergeant military fitness)
- Boxing
- Boxing class (e.g. Boxercise body combat)
- Cardio class (e.g. aerobics step aerobics body attack)
- Circuit or cross training, cross fit, HIT or boot camp
- Circuit training
- Cross fit
- Cross training
- Cycle class (e.g. spinning RPM)
- Cyclo-cross
- Fell or trail running
- Field hockey
- Futsal
- High intensity (e.g. HIT insanity)
- Hockey
- Indoor cycling - in a class
- Ju-Jitsu
- Karate
- Mountain biking
- Obstacle course (e.g. Tough Mudder Spartan Rat Race)
- Parkour or free running
- Road cycling or racing
- Rugby union
- Running or jogging
- Small sided football
- Squash or racketball
- Taekwondo
- Track and field athletics
- Triathlon (includes aquathlon and duathlon)
- Weightlifting or powerlifting (using a barbell)

Moderate Exercises

Definition: Activity capped: Moderate intensity minutes per week: Sport (count definition), capped at 1680 mins/wk.

- A session combining several gym or fitness machines or activities
- Aikido
- Badminton
- Baseball or softball
- Basketball
- BMX
- Body weight exercises (e.g. pull ups press ups sit ups)
- Cheerleading
- Chinese martial arts
- Climbing or bouldering wall
- Climbing or mountaineering
- Cross training machine (e.g. Cross trainer SkiErg)
- Cycling for leisure
- Cycling for leisure
- Cycling for Leisure and all other cycling
- Cycling for travel (including commuting)
- Cycling for travel incl commuting
- Dance-based class (e.g. Zumba fitsteps ravercise or body jam)
- Dance-based class (e.g. Zumba, fitsteps, ravercise or body jam)
- Dressage
- Eventing
- Exercise bike
- Exercise machine
- Football
- Free weights (includes kettlebells and dumb-bells)
- Gymnastics
- Gymnastics or trampolining
- Handball
- Hill and mountain walking, hiking, mountaineering
- Hill or mountain walking or hiking
- Hill or mountain walking or hiking
- Indoor cycling - not in a class
- Judo
- Lacrosse
- Martial arts
- Mountaineering and scrambling
- Netball
- Other exercise machine
- Other football
- Other horse riding
- Resistance weights machines
- Rock climbing or bouldering
- Rounders
- Rounders
- Rowing
- Rowing machine
- Rowing machine
- Rugby league
- Rugby sevens
- Running machine or treadmill
- Schooling
- Show jumping
- Skiing
- Skiing or snowboarding

- Skipping
- Snowboarding
- Step machine
- Surfing, body surfing or body boarding
- Tag or other rugby league
- Tag or other rugby union
- Tennis
- Touch rugby
- Touch rugby league
- Touch rugby league
- Touch rugby union
- Touch rugby union
- Track cycling
- Trampolining
- Treadmill
- Volleyball
- Walking football
- Water based rowing
- Water polo
- Water polo
- Water-based class (e.g. aquaerobics aquafit)
- Weights (did not specify whether free weights or resistance weights)
- Weights-based class (e.g. body pump kettlebell)
- Wrestling

Youths

Moderate and vigorous activities are encompassed under the same variable (original variable name: mins_modplus_outschool_Week_ALL). Deinition: Mins spent in week (moderate plus mins) outside school: All activities

According to Sports England (2024), activities were categorized based on the following definition:

> Moderate activity: This is defined as activity where you raise your heart rate and feel a little out of breath (In academic year 2017-18 (Year 1) pupils were asked whether it made them breathe faster, but since academic year 2019-20 (Year 3) have been asked whether it made them breathe faster than sitting down reading. In Year 2 (18-19), half the children were asked the year 3 version and half were asked the year 1 version across the whole year).
>
> Vigorous activity: This is defined as when you are out of breath or are sweating - you may not be able to say more than a few words without pausing for breath (pupils were asked whether it made them hot or tired).

More specifically, these acvities were included

- Cycling for fun
- Dancing (include online or TV led e.g. TikTok dances)
- Trampolining (including in a garden, at a trampoline centre, or as part of a club)
- Playing it, tag, chase, sardines or other running game
- Football
- Netball
- Hockey
- Rugby (including tag rugby)

- Touch or tag Rugby
- Contact rugby (rugby union)
- Rugby league (contact)
- Basketball
- Cheerleading
- Running, jogging, cross-country
- Field athletics
- Gym or fitness (fitness/online class e.g., push-ups, sit-ups, yoga, etc or using exercise machines e.g. rowing machine, exercise bike, running machine)
- Judo, karate, taekwondo and other martial arts
- Sports day events
- Boxing

Appendix C - Other tables

Table 8: Statistics on Likert-scale responses in adults.

Variable	Mean	Median	SD	PercentNA
Enjoyment	2.126	2.0	1.0249	4.344
Social	2.887	3.0	1.1603	6.383
Fitness	1.863	2.0	0.8631	3.942
Guilt	2.553	2.0	1.1045	5.036
Opportunity	2.010	2.0	0.9913	4.018
Importance	1.980	2.0	0.9118	4.214
Challenge	2.757	3.0	1.1512	6.143
Relaxation	2.263	2.0	1.0125	5.332
Minutes.Exercised	493.496	337.5	475.1089	0.000

Table 9: Statistics on Likert-scale responses in youths.

Variable	Mean	Median	SD	PercentNA
Enjoyment	1.653	2	0.7189	9.818
Social	2.185	2	0.8673	42.212
Fitness	1.780	2	0.7032	40.950
Opportunity	1.613	2	0.6290	39.725
Guilt	2.521	3	0.9115	42.623
Importance	1.414	1	0.5802	6.787
Challenge	1.871	2	0.7528	16.348
Relaxation	2.224	2	0.9051	42.035
Minutes.Exercised	426.587	290	427.9877	1.044

Appendix D - R Code (Data Cleaning)

```
> # Library ----------------------------------------------------------------
> set.seed(2025)

> library(tidyverse)

> library(car)

> # Read Data --------------------------------------------------------------
> #
> # data.child <- read.csv('data/child_main.tab', header=T, sep='\t')
> # data.adult <- read.csv('data/adult.tab', header=T, sep='\t')
>
> # Read relevant fields
> # child.var <- data.child %>% select(# likert predictors
>                                     # 'PL_Enjoy_bc_ans', 'PL_Conf_bc_ans',
>                                     # 'PL_Easy_bc_ans', 'PL_GdMe_bc_ans',
>                                     # 'PL_Know_c_ans', 'MO_Opp_c',
>                                     # 'MO_Fit_c', 'MO_Relax_c', 'MO_Fun_c',
>                                     # 'MO_Guilt_c', 'MO_Haveto_b_36',
>                                     # 'MO_Haveto_c_711', 'PR_Fam_c', 'PR_Oth_c',
>                                     # 'Try_bc', 'outdoor_bcd_Overall',
>                                     # 'Exeramt_bc', 'ExeramtMore_bc1_2',
>                                     # 'ExeramtMore_bc2_2', 'ExeramtMore_bc3_2',
>                                     # 'mins_modplus_outschool_Week_ALL',
>                                     #
>                                     # # demographic
>                                     # 'age_11', 'eth2', 'gend3', 'eth6',
>                                     # 'Disab_All_POP',
>                                     #
>                                     # # binary predictors
>                                     # 'PL_Enjoy_bc_SA_gr2', 'MO_Fun_c_SA',
>                                     # 'MO_Fit_c_SA',
>                                     # 'MO_Guilt_c_SA', 'MO_Opp_c_SA',
>                                     # 'MO_Relax_c_SA'
> # )
>
> # Save to save computation time
> # save(child.var, file = "child.var.RData")
> #
>
> # Same process for adults, different variables
> # adult.var <- data.adult %>% dplyr::select('Motiva_POP','motivb_POP',
> #                                           'motivc_POP','motivd_POP',
> #                                           'motive_POP','READYAB1_POP',
> #                                           'READYOP1_POP','motivex2a',
> #                                           'motivex2b','motivex2c',
> #                                           'motivex2d','inclus_a',
> #                                           'inclus_b','inclus_c',
> #                                           'indev','indevtry',
> #                                           'workactlvl',
> #                                           'DUR_HVY_CAPPED_SPORTCOUNT_A01',
```

```
> #                                           'DUR_MOD_CAPPED_SPORTCOUNT_A01',
> #
> #                                           # demographic
> #                                           'Age17','Age3','AgeTGC',
> #                                           'Age4','Age5','Age5_2',
> #                                           'Age9','Disab2_POP',
> #                                           'Gend3','Eth2','Eth7',
> #                                           'Educ6',
> #
> #                                           # binary predictors
> #                                           'Motiva_POP_GR2', 'motivex2c_GR2',
> #                                           'motivex2a_GR2', 'motivc_POP_GR2',
> #                                           'READYOP1_POP_GR2','motivex2b_GR2')
> #
> # save(adult.var, file = "adult.var.RData")
>
> # Basic Distributions and Stats -------------------------------------------
>
> load("child.var.RData")

> load("adult.var.RData")

> glimpse(child.var)
Rows: 122,347
Columns: 32
$ PL_Enjoy_bc_ans                 <int> 4, 1, 2, 2, 1, 5, 1, 4, 2, 1, 2, 1, 1,~
$ PL_Conf_bc_ans                  <int> 4, 1, 2, 3, 1, 2, 1, 2, 1, 1, 2, 2, 2,~
$ PL_Easy_bc_ans                  <int> 4, 2, 2, 3, 2, 3, 2, 2, 2, 1, 5, 3, 3,~
$ PL_GdMe_bc_ans                  <int> 1, 1, 2, 2, 1, 1, 1, 2, 5, 1, 2, 1, 2,~
$ PL_Know_c_ans                   <int> 2, 2, 2, 2, 1, 2, 1, -98, -98, -98, -9~
$ MO_Opp_c                        <int> 1, 2, 2, 2, 1, 2, 1, -98, -98, -98, -9~
$ MO_Fit_c                        <int> 99, 1, 2, 3, 2, 2, 1, -98, -98, -98, -~
$ MO_Relax_c                      <int> 3, 1, 3, 3, 2, 3, 1, -98, -98, -98, -9~
$ MO_Fun_c                        <int> 4, 2, 3, 2, 3, 3, 3, -98, -98, -98, -9~
$ MO_Guilt_c                      <int> 4, 1, 2, 3, 1, 4, 2, -98, -98, -98, -9~
$ MO_Haveto_b_36                  <int> -98, -98, -98, -98, -98, -98, -98, 1, ~
$ MO_Haveto_c_711                 <int> 2, 4, 3, 3, 3, 2, 4, -98, -98, -98, -9~
$ PR_Fam_c                        <int> 4, 3, 2, 3, 3, 2, 3, -91, -91, -91, -9~
$ PR_Oth_c                        <int> 2, 5, 2, 2, 3, 2, 3, -91, -91, -91, -9~
$ Try_bc                          <int> 5, 1, 2, 3, 2, 1, 1, 2, 2, 2, 2, 1, 2,~
$ outdoor_bcd_Overall             <int> 3, 3, 3, 2, 3, 3, 3, -98, -98, -98, -9~
$ Exeramt_bc                      <int> 1, 2, 1, 1, 1, 1, 1, 3, 1, 1, 3, 1, 1,~
$ ExeramtMore_bc1_2               <int> 1, -98, 0, 1, 0, 0, 0, -98, 1, 1, -98,~
$ ExeramtMore_bc2_2               <int> 0, -98, 0, 0, 0, 1, 1, -98, 1, 1, -98,~
$ ExeramtMore_bc3_2               <int> 0, -98, 1, 0, 1, 0, 0, -98, 0, 0, -98,~
$ mins_modplus_outschool_Week_ALL <int> 330, -96, 90, 60, 0, 95, 490, 0, 840, ~
$ age_11                          <int> 12, 12, 12, 13, 12, 13, 13, 10, 10, 9,~
$ eth2                            <int> 2, 2, 2, 1, 2, 3, 1, 2, 2, 2, 1, 3, 3,~
$ gend3                           <int> 2, 2, 2, 2, 2, 2, 2, 1, 1, 1, 3, 1, 2,~
$ eth6                            <int> 3, 3, 3, 1, 2, 7, 1, 5, 3, 4, 1, 7, 7,~
$ Disab_All_POP                   <int> 2, 3, 3, 2, 2, 2, 2, 1, 1, 2, 4, 2, 2,~
$ PL_Enjoy_bc_SA_gr2              <int> 2, 1, 2, 2, 1, 99, 1, 2, 2, 1, 2, 1, 1~
$ MO_Fun_c_SA                     <int> 2, 2, 2, 2, 2, 2, 2, -98, -98, -98, -9~
$ MO_Fit_c_SA                     <int> 99, 1, 2, 2, 2, 2, 1, -98, -98, -98, -~
```

```
$ MO_Guilt_c_SA                  <int> 2, 1, 2, 2, 1, 2, 2, -98, -98, -98, -9~
$ MO_Opp_c_SA                    <int> 1, 2, 2, 2, 1, 2, 1, -98, -98, -98, -9~
$ MO_Relax_c_SA                  <int> 2, 1, 2, 2, 2, 2, 1, -98, -98, -98, -9~

> glimpse(adult.var)
Rows: 172,968
Columns: 37
$ Motiva_POP                   <int> 1, 3, 2, 1, -95, -98, 2, 5, 2, 2, 1, 2, ~
$ motivb_POP                   <int> 1, 2, 2, 2, 3, 2, 2, 3, 2, 3, 2, 3, 1, 1~
$ motivc_POP                   <int> 2, -95, -98, 2, 3, 2, 2, -99, 3, 4, 3, 3~
$ motivd_POP                   <int> 3, 5, 4, 2, 3, -98, 5, -99, 3, 3, 5, 3, ~
$ motive_POP                   <int> -98, -99, -98, -98, -99, -98, -99, -99, ~
$ READYAB1_POP                 <int> 1, -95, 2, 2, 3, -95, 2, 2, 1, 2, 1, 2, ~
$ READYOP1_POP                 <int> 1, 5, 2, 2, 3, -95, 2, 2, 2, 2, 1, 2, 1,~
$ motivex2a                    <int> 1, 2, 2, 2, 3, 1, 2, 2, 3, 2, 1, 3, 1, 1~
$ motivex2b                    <int> 1, 3, 2, 2, 3, 2, 2, 2, 3, 3, 2, 3, 1, 2~
$ motivex2c                    <int> 2, 3, -95, 2, 3, 4, 2, 3, 3, 2, 1, 2, 3,~
$ motivex2d                    <int> 2, 3, 2, 2, 3, -95, 4, 2, 3, 3, 3, 3, 2,~
$ inclus_a                     <int> 1, -98, -95, 2, -98, 4, -98, -98, 3, 2, ~
$ inclus_b                     <int> 2, -98, 2, 2, -98, -98, -98, -98, 4, 2, ~
$ inclus_c                     <int> 2, -98, -95, 2, -98, -95, -98, -98, 4, 2~
$ indev                        <int> 5, -98, 4, 1, -98, 4, -98, -98, -98, -98~
$ indevtry                     <int> 4, -98, 3, 4, -98, 4, -98, -98, -98, -98~
$ workactlvl                   <int> -98, -98, 1, 2, -98, 2, -98, -98, -98, 2~
$ DUR_HVY_CAPPED_SPORTCOUNT_A01 <dbl> 0, 0, 0, 0, 0, 210, 0, 0, 0, 0, 0, 180, ~
$ DUR_MOD_CAPPED_SPORTCOUNT_A01 <dbl> 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00~
$ Age17                        <int> 10, 11, 2, 3, 9, 6, 10, 15, 12, 10, 7, 4~
$ Age3                         <int> 3, 3, 1, 1, 3, 2, 3, 3, 3, 3, 2, 1, 3, 2~
$ AgeTGC                       <int> 3, 3, 1, 1, 2, 2, 3, 3, 3, 2, 2, 1, 2, 2~
$ Age4                         <int> 3, 3, 1, 1, 3, 2, 3, 4, 3, 3, 2, 1, 3, 2~
$ Age5                         <int> 4, 5, 2, 3, 4, 3, 4, 5, 5, 4, 4, 3, 4, 4~
$ Age5_2                       <int> 5, 5, 1, 2, 5, 3, 5, 5, 5, 5, 4, 2, 5, 4~
$ Age9                         <int> 6, 7, 2, 3, 6, 4, 6, 9, 7, 6, 5, 3, 6, 5~
$ Disab2_POP                   <int> 2, 1, 2, 2, 1, -94, 2, 1, 2, 2, 2, 2, 2,~
$ Gend3                        <int> 1, 1, 2, 1, 2, 2, 1, 1, 2, 1, 2, 2, 1, 1~
$ Eth2                         <int> 2, 1, 2, -94, 1, 2, 1, 2, 2, 1, 1, 1, 1,~
$ Eth7                         <int> 2, 1, 3, -94, 1, 2, 1, 4, 3, 1, 1, 1, 1,~
$ Educ6                        <int> 1, 6, 3, 3, 6, 1, 1, 6, 6, 1, 1, 2, 1, 2~
$ Motiva_POP_GR2               <int> 1, 0, 0, 1, -95, -98, 0, 0, 0, 0, 1, 0, ~
$ motivex2c_GR2                <int> 0, 0, -95, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0,~
$ motivex2a_GR2                <int> 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 1, 1~
$ motivc_POP_GR2               <int> 0, -95, -98, 0, 0, 0, 0, -99, 0, 0, 0, 0~
$ READYOP1_POP_GR2             <int> 1, 0, 0, 0, 0, -95, 0, 0, 0, 0, 1, 0, 1,~
$ motivex2b_GR2                <int> 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0~

> # ethnicity
> prop.table(table(adult.var$Eth7))

> prop.table(table(child.var$eth6))

> # 2 is no disa
> table(child.var$Disab_All_POP)

> table(adult.var$Disab2_POP)
```

```
> # adult in bands of 5 years, child just in years
> table(child.var$age_11)

> table(adult.var$Age19plus)

> # too few transgendered adults, filter out
> table(adult.var$gend2_GR6)

> table(adult.var$indevtry)

> table(adult.var$motive_POP)

> # Clean Data for SEM ------------------------------------------------------
>
>
> child.bi <- child.var %>%
+   filter(Disab_All_POP == 2, # remove disabled and no answer
+          gend3 %in% c(1,2),
+          eth2 %in% c(1,2),
+
+          if_all(c(age_11, mins_modplus_outschool_Week_ALL), ~ .x > -1),
+
+          if_all(c(PL_Enjoy_bc_SA_gr2, MO_Fun_c_SA, MO_Fit_c_SA,
+                   MO_Guilt_c_SA, MO_Opp_c_SA, MO_Relax_c_SA), ~ .x > -1 & .x < 3)) %>%
+
+   dplyr::select(enjoyb=PL_Enjoy_bc_SA_gr2,
+                 socialb=MO_Fun_c_SA,
+                 fitb=MO_Fit_c_SA,
+                 guiltb=MO_Guilt_c_SA,
+                 oppb=MO_Opp_c_SA,
+                 relxb=MO_Relax_c_SA,
+
+                 gender=gend3,
+                 age=age_11,
+                 eth=eth2,
+                 mins=mins_modplus_outschool_Week_ALL
+
+   ) %>%
+
+
+   # change 2 (not strongly agree) to 0, consistent with adult
+   mutate(across(c(enjoyb,socialb,fitb,guiltb,oppb,relxb), ~ ifelse(.x==2, 0, .x)),
+          gender = gender-1,
+          eth = eth-1,
+          age = age-11)

> adult.bi <- adult.var %>% filter(Disab2_POP==2,
+                                  Gend3 %in% c(1,2),
+                                  Eth2 %in% c(1,2),
+                                  if_all(c(AgeTGC,
+                                           DUR_MOD_CAPPED_SPORTCOUNT_A01,
+                                           DUR_HVY_CAPPED_SPORTCOUNT_A01),
+                                         ~ .x > -1),
```

```
+                                   if_all(c(Motiva_POP_GR2, motivex2c_GR2,
+                                            motivex2a_GR2, motivc_POP_GR2,
+                                            READYOP1_POP_GR2, motivex2b_GR2),
+                                          ~ .x %in% c(0,1))) %>%
+
+
+   mutate(mins=DUR_MOD_CAPPED_SPORTCOUNT_A01 +
+            DUR_HVY_CAPPED_SPORTCOUNT_A01,
+          Gend3 = Gend3-1,
+          Eth2 = Eth2-1,
+          age = case_when(Age9==2~3L,
+                          Age9==9~8L,
+                          TRUE~as.integer(Age9)),
+          age=as.integer(age-3)
+   ) %>%
+
+
+   dplyr::select(enjoyb=Motiva_POP_GR2,
+                 socialb=motivex2c_GR2,
+                 fitb=motivex2a_GR2,
+                 guiltb=motivc_POP_GR2,
+                 oppb=READYOP1_POP_GR2,
+                 relxb=motivex2b_GR2,
+                 gender=Gend3,
+                 age,
+                 eth=Eth2,
+                 mins
+   )

> dallb <- bind_rows(
+   adult.bi %>% mutate(group = "adult"),
+   child.bi %>% mutate(group = "youth")
+ ) %>%
+   mutate(mins = ifelse(mins > 1680, 1680, mins))

> dallb$gender <- relevel(factor(dallb$gender), ref = "0")

> dallb$eth <- relevel(factor(dallb$eth), ref = "0")

> # Clean Data for LCA ------------------------------------------------------
>
> # # Check if collapsing is necessary
> # child.lik %>% dplyr::select(-max_post,-mins,-age,-eth) %>%
> #   pivot_longer(
> #     cols = everything(),   # or specify your Likert vars if df has other columns
> #     names_to = "Variable",
> #     values_to = "Response"
> #   ) %>%
> #   group_by(Variable, Response) %>%
> #   summarise(n = n(), .groups = "drop_last") %>%
> #   #"drop_last" drops the response variable,
> #   #so that the next part (proportion) does not calculate within each response
> #
> #   mutate(prop = n / sum(n)) %>%
```

```
> #   arrange(Variable, Response) %>% filter(prop < 0.05)
>
> # Check which motive responses need to be collapsed
> prop.table(table(child.var$PL_Enjoy_bc_ans))

> prop.table(table(child.var$MO_Fun_c))

> prop.table(table(child.var$MO_Fit_c))

> prop.table(table(child.var$MO_Opp_c))

> prop.table(table(child.var$MO_Guilt_c))

> prop.table(table(child.var$MO_Relax_c))

> prop.table(table(child.var$PL_Conf_bc_ans))

> prop.table(table(child.var$PL_GdMe_bc_ans))

> prop.table(table(child.var$Try_bc))

> prop.table(table(adult.var$Motiva_POP))

> prop.table(table(adult.var$motivex2c))

> prop.table(table(adult.var$motivex2a))

> prop.table(table(adult.var$motivc_POP))

> prop.table(table(adult.var$READYOP1_POP))

> prop.table(table(adult.var$READYAB1_POP))

> prop.table(table(adult.var$motivb_POP))

> prop.table(table(adult.var$motivex2d))

> prop.table(table(adult.var$motivex2b))

> child.lik <- child.var %>%
+
+   # 1-4, 1=strong agree, 4=strong disagree, 5=can't say
+   dplyr::select(enjoy=PL_Enjoy_bc_ans,
+                 social=MO_Fun_c,
+                 fit=MO_Fit_c,
+                 opp=MO_Opp_c,
+                 guilt=MO_Guilt_c, #99 instead of 5 for "can't say"
+                 relx=MO_Relax_c,
+
+                 abl=PL_Conf_bc_ans,
+                 imp=PL_GdMe_bc_ans,
+                 chal=Try_bc,
+
+                 dsbl=Disab_All_POP,
```

```
+                 gender=gend3,
+                 age=age_11,
+                 eth=eth2,
+                 mins=mins_modplus_outschool_Week_ALL
+   ) %>%
+
+   filter(dsbl == 2,
+          gender %in% c(1,2),
+          eth %in% c(1,2),
+          mins > -1,
+          if_all(c(enjoy,social,fit,guilt,opp,imp,chal,relx,abl),
+                 ~ .x > -1 & .x < 5)) %>%
+   mutate(
+     mins = ifelse(mins > 1680, 1680, mins),
+     across(c(enjoy,social,fit,guilt,imp,chal,opp,relx,abl),
+            ~ case_when(.x==4~3L, TRUE ~ as.integer(.x))),
+     age=age-10
+
+
+   ) %>%
+   dplyr::select(-dsbl)

> child.lik.back0 <- child.lik

> adult.lik <- adult.var %>%
+   mutate(mins=DUR_HVY_CAPPED_SPORTCOUNT_A01+DUR_MOD_CAPPED_SPORTCOUNT_A01) %>%
+
+   # 1=strong agree, 5=strong disagree
+   dplyr::select(enjoy=Motiva_POP,
+                 social=motivex2c,
+                 fit=motivex2a,
+                 guilt=motivc_POP,
+                 opp=READYOP1_POP,
+
+                 abl=READYAB1_POP,
+                 imp=motivb_POP,
+                 chal=motivex2d,
+                 relx=motivex2b,
+
+                 dsbl=Disab2_POP,
+                 gender=Gend3,
+                 age=Age9,
+                 eth=Eth2,
+                 # edu=Educ6,
+                 mins
+   ) %>%
+
+   filter(dsbl==2,
+          if_all(c(gender,eth), ~ .x %in% c(1,2)),
+          if_all(everything(), ~ .x > -1)
+          # edu != 5
+   ) %>%
+
+   mutate(across(c(enjoy,social,fit,guilt,opp,imp,chal,relx,abl),
```

```
+                  ~ case_when(.x==5~4L, TRUE ~ as.integer(.x))),
+           # edu = case_when(edu==6~5L, TRUE~edu),
+           age = as.integer(case_when(age==2~3L,
+                           age==9~8L,
+                           TRUE~as.integer(age)))-2
+
+   ) %>%
+
+
+   dplyr::select(-dsbl)

> adult.lik.back0 <- adult.lik

> # Checks ---------------------------------------------------------------------
> # Collinearity
> dallb1 <- dallb %>% dplyr::select(-gender,-eth,-group)

> cor(dallb1, method = "pearson")

> # opp, fit and enjoy have mod corr with each other, others ok
>
> # Check adult lik corr
> cor(child.lik.back0 %>% dplyr::select(-gender,-eth, -age), method = "pearson")

> cor(adult.lik.back0 %>% dplyr::select(-gender,-eth,-age), method = "pearson")

> # Check sparsity of highly correlated (>.05) items
> prop.table(table(child.lik$abl, child.lik$enjoy))

> prop.table(table(adult.lik$fit, adult.lik$enjoy))

> prop.table(table(adult.lik$imp, adult.lik$enjoy))

> prop.table(table(adult.lik$fit, adult.lik$imp))

> prop.table(table(adult.lik$abl, adult.lik$opp))

> child.lik.back <- child.lik

> adult.lik.back <- adult.lik

> # VIF
> vif_model <- lm(mins ~ enjoyb + socialb + fitb + guiltb + oppb + relxb, data = dallb1)

> vif(vif_model)
```

Appendix E - R Code (SEM)

```
> # Libraries ---------------------------------------------------------------------
> set.seed(2025)

> library(tidyverse)

> library(lavaan)

> # SEM -------------------------------------------------------------------------
>
> # Free model
> m0 <- '
+   # Mediators: controlling for age, gender, and ethnicity (group-specific coefficients)
+   enjoyb ~ c(a1_adult, a1_youth)*age + c(g1_adult, g1_youth)*gender + c(e1_adult, e1_youth)*eth
+   guiltb ~ c(a2_adult, a2_youth)*age + c(g2_adult, g2_youth)*gender + c(e2_adult, e2_youth)*eth
+   oppb   ~ c(a3_adult, a3_youth)*age + c(g3_adult, g3_youth)*gender + c(e3_adult, e3_youth)*eth
+   fitb   ~ c(a4_adult, a4_youth)*age + c(g4_adult, g4_youth)*gender + c(e4_adult, e4_youth)*eth
+   socialb~ c(a5_adult, a5_youth)*age + c(g5_adult, g5_youth)*gender + c(e5_adult, e5_youth)*eth
+   relxb~ c(a6_adult, a6_youth)*age + c(g6_adult, g6_youth)*gender + c(e6_adult, e6_youth)*eth
+
+   # Main outcome: motives predicting mins, controlling for demographics (group-specific coefficients)
+   mins ~ c(b1_adult, b1_youth)*enjoyb + c(b2_adult, b2_youth)*guiltb + c(b3_adult, b3_youth)*oppb +
+           c(b4_adult, b4_youth)*fitb + c(b5_adult, b5_youth)*socialb + c(b6_adult, b6_youth)*relxb
+           + c(c_adult, c_youth)*age +
+           c(g7_adult, g7_youth)*gender + c(e7_adult, e7_youth)*eth
+
+ # For Adults
+ indirect_age_enjoyb_adult  := a1_adult * b1_adult
+ indirect_age_guiltb_adult  := a2_adult * b2_adult
+ indirect_age_oppb_adult    := a3_adult * b3_adult
+ indirect_age_fitb_adult    := a4_adult * b4_adult
+ indirect_age_socialb_adult := a5_adult * b5_adult
+ indirect_age_relxb_adult := a6_adult * b6_adult
+ total_age_adult := c_adult + indirect_age_enjoyb_adult + indirect_age_guiltb_adult +
+                     indirect_age_oppb_adult + indirect_age_fitb_adult +
+                     indirect_age_socialb_adult + indirect_age_relxb_adult
+
+ # For Youth
+ indirect_age_enjoyb_youth  := a1_youth * b1_youth
+ indirect_age_guiltb_youth  := a2_youth * b2_youth
+ indirect_age_oppb_youth    := a3_youth * b3_youth
+ indirect_age_fitb_youth    := a4_youth * b4_youth
+ indirect_age_socialb_youth := a5_youth * b5_youth
+ indirect_age_relxb_youth := a6_youth * b6_youth
+ total_age_youth := c_youth + indirect_age_enjoyb_youth + indirect_age_guiltb_youth +
+                    indirect_age_oppb_youth + indirect_age_fitb_youth +
+                    indirect_age_socialb_youth + indirect_age_relxb_youth
+ '

> f0 <- sem(m0, data = dallb, group = "group")
```

```
> sem.free <- summary(f0, fit.measures = TRUE, standardized = TRUE)

> # Constrain all to be equal
> f.con <- sem(m0, dallb, group = "group",
+              group.equal = c("intercepts", "regressions"))


> # Check if significantly different
> f0fcon <- anova(f0, f.con)

> f0fcon

> # Spec one constraint at a time
> m1 <- '
+   # Mediators
+   enjoyb ~ age + gender + eth
+   guiltb ~ age + gender + eth
+   oppb ~ age + gender + eth
+   fitb ~ age + gender + eth
+   socialb ~ age + gender + eth
+   relxb ~ age + gender + eth
+
+   # Main outcome
+   mins ~ c("a1","a1")*enjoyb + guiltb + oppb + fitb + socialb + age + gender + eth + relxb
+ '

> m2 <- '
+   # Mediators
+   enjoyb ~ age + gender + eth
+   guiltb ~ age + gender + eth
+   oppb ~ age + gender + eth
+   fitb ~ age + gender + eth
+   socialb ~ age + gender + eth
+   relxb ~ age + gender + eth
+
+   # Main outcome
+   mins ~ enjoyb + c(a,a)*guiltb + oppb + fitb + socialb + age + gender + eth + relxb
+ '

> m3 <- '
+   # Mediators
+   enjoyb ~ age + gender + eth
+   guiltb ~ age + gender + eth
+   oppb ~ age + gender + eth
+   fitb ~ age + gender + eth
+   socialb ~ age + gender + eth
+   relxb ~ age + gender + eth
+
+   # Main outcome
+   mins ~ enjoyb + guiltb + c(a,a)*oppb + fitb + socialb + age + gender + eth + relxb
+ '

> m4 <- '
+   # Mediators
```

```
+   enjoyb ~ age + gender + eth
+   guiltb ~ age + gender + eth
+   oppb ~ age + gender + eth
+   fitb ~ age + gender + eth
+   socialb ~ age + gender + eth
+   relxb ~ age + gender + eth
+
+   # Main outcome
+   mins ~ enjoyb + guiltb + oppb + c(a,a)*fitb + socialb + age + gender + eth + relxb
+ '

> m5 <- '
+   # Mediators
+   enjoyb ~ age + gender + eth
+   guiltb ~ age + gender + eth
+   oppb ~ age + gender + eth
+   fitb ~ age + gender + eth
+   socialb ~ age + gender + eth
+   relxb ~ age + gender + eth
+
+   # Main outcome
+   mins ~ enjoyb + guiltb + oppb + fitb + c(a,a)*socialb + age + gender + eth + relxb
+ '

> m6 <- '
+   # Mediators
+   enjoyb ~ age + gender + eth
+   guiltb ~ age + gender + eth
+   oppb ~ age + gender + eth
+   fitb ~ age + gender + eth
+   socialb ~ age + gender + eth
+   relxb ~ age + gender + eth
+
+   # Main outcome
+   mins ~ enjoyb + guiltb + oppb + fitb + c(a,a)*relxb + age + gender + eth + socialb
+ '

> # Small eigenvalue close to 0, does not matter
> f1 <- sem(m1, data = dallb, group = "group", meanstructure = TRUE)


> f2 <- sem(m2, data = dallb, group = "group", meanstructure = TRUE)


> f3 <- sem(m3, data = dallb, group = "group", meanstructure = TRUE)


> f4 <- sem(m4, data = dallb, group = "group", meanstructure = TRUE)


> f5 <- sem(m5, data = dallb, group = "group", meanstructure = TRUE)


> f6 <- sem(m6, data = dallb, group = "group", meanstructure = TRUE)
```

```
> # Check all models are significantly different from m0
> anova(f0, f1)

> anova(f0, f2)

> anova(f0, f3)

> anova(f0, f4)

> anova(f0, f5)

> anova(f0, f6)

> # Put slope diff. in a table
> params <- parameterEstimates(f0, standardized = T)

> # filter
> slopes <- params %>%
+   filter(lhs == "mins", op == "~") %>%
+   dplyr::select(var=rhs, group, est, se)

> # filtre more
> slopes.ad <- slopes %>% filter(group == 1) %>%
+   dplyr::select(var, est.adult = est, se.adult = se)

> slopes.ch <- slopes %>% filter(group == 2) %>%
+   dplyr::select(var, est.youth = est, se.youth = se)

> # join!
> slopes.diff <- data.frame()

> slopes.diff <- left_join(slopes.ch, slopes.ad, by = "var")

> # calculate
> slopes.diff <- slopes.diff %>%
+   mutate(
+     diff = est.youth - est.adult
+   ) %>%
+   filter(!var %in% c("gender","eth","age")) %>%
+   dplyr::select(-se.youth, -se.adult)

> # check residual
> resid(f0, type = "cor")
```

Appendix F - R Code (LCA)

```
> # Libraries ----------------------------------------------------------------
> set.seed(2025)

> library(tidyverse)

> library(Hmisc)

> library(ggplot2)

> library(nnet)

> library(tidyLPA)

> library(poLCA)

> library(poLCAExtra)

> # LCA, Youths --------------------------------------------------------------
> child.lik <- child.lik.back

> # Predictors (motives)
> child.lik.y <- (child.lik %>%
+                            dplyr::select(-mins,-age,-gender,-eth))

> child.lik.y <- as.matrix(child.lik.y %>% mutate(across(everything(), as.integer)))

> # Spec formula for LCA
> lca.f.child <- child.lik.y ~ gender + eth

> # Run LCA with 2-7 classes
> # LCAE.ch <- poLCA(lca.f.child, data = child.lik, nclass = 2:7)
> # save(LCAE.ch, file="LCAE.ch.RData")
> load("LCAE.ch.RData")

> # bootstrapped Vuong-Lo-Mendell-Rubin likelihood ratio test
> # blrt.ch <- poLCA.blrt(LCAE.ch,quick = T, nrep=10)
> # save(blrt.ch,file="blrt.ch.RData")
> # load("blrt.ch.RData")
>
>
> # Output
> ch.lca.output <- LCAE.ch$output %>% dplyr::select(nclass,llike,AIC,BIC,
+                                                        Rel.Entropy,LMR,p)

> ch.lca.output

> # check max posterior
> # for(k in 2:4){
> #
> #   child.lik$post <- apply(LCAE.ch$LCA[[k]]$posterior, 1, max)
> #
```

```
> #   child.lik$class <- LCAE.ch$LCA[[k]]$predclass
> #
> #   print(
> #     ggplot(child.lik, aes(x = post, fill = factor(class))) +
> #     geom_histogram(binwidth = 0.05, alpha = 0.7, position = "identity") +
> #     labs(x = "Max Posterior Probability", y = "Count", fill = "Class",
> #          title = paste0(k+1," Classes, Youths")) +
> #     theme_minimal()
> #   )
> #
> #   print(ggplot(child.lik, aes(x = factor(class), y = post)) +
> #     geom_boxplot(fill = "skyblue") +
> #     labs(x = "Class", y = "Max Posterior Probability",
> #          title = paste0(k+1," Classes, Youths")) +
> #     theme_minimal()
> #   )
> # }
>
> # Compare 3 and 4 class average posterior and class prop
> post4.ch <- LCAE.ch$LCA[[3]]$posterior

> class4.ch <- apply(post4.ch, 1, which.max)

> class.size4.ch <- prop.table(table(class4.ch))

> ave.pp4.ch <- sapply(1:ncol(post4.ch), function(k) {
+   inds <- which(class4.ch == k)
+   mean(post4.ch[inds, k])
+ })

> post3.ch <- LCAE.ch$LCA[[2]]$posterior

> class3.ch <- apply(post3.ch, 1, which.max)

> class.size3.ch <- prop.table(table(class3.ch))

> ave.pp3.ch <- sapply(1:ncol(post3.ch), function(k) {
+   inds <- which(class3.ch == k)
+   mean(post3.ch[inds, k])
+ })

> # BEST CLASS decided
> # 3 classes is best
> lca.best.ch <- LCAE.ch$LCA[[2]]

> child.lik$class <- lca.best.ch$predclass

> # child.lik$post <- apply(lca.best.ch$posterior, 1, max)
>
> # Calculate median minutes
> n.classes <- 3

> wmed.ch <- numeric(n.classes)
```

```
> wq25.ch <- numeric(n.classes)

> wq75.ch <- numeric(n.classes)

> for (k in 1:n.classes) {
+
+   q <- wtd.quantile(child.lik$mins,
+                     weights = lca.best.ch$posterior[,k],
+                     probs = c(0.25, 0.5, 0.75))
+   wq25.ch[k] <- q[1]
+   wmed.ch[k] <- q[2]
+   wq75.ch[k] <- q[3]
+ }

> # Regressions
> child.lik$age <- child.lik.back$age

> child.lik$class <- relevel(factor(child.lik$class), ref = "1")

> child.lik$age <- relevel(factor(child.lik$age), ref = "1")

> fit.ch <- multinom(class ~ age,
+                    data = child.lik)
# weights:  21 (12 variable)
initial  value 31056.670788
iter  10 value 28676.812139
final  value 28091.735008
converged

> # odds ratio
> or.ch <- exp(coef(fit.ch))

> or.ch

> sum.fit.ch <- summary(fit.ch)

> se <- sum.fit.ch$standard.errors

> # Coefficients
> coefs.ch <- coef(fit.ch)

> # 95% CI for odds ratios
> ci.l.ch <- exp(coefs.ch - 1.96 * se)

> ci.u.ch <- exp(coefs.ch + 1.96 * se)

> # Odds ratios themselves
> or <- exp(coefs.ch)

> # Combine into a table
> or.ci.ch <- data.frame(
+   CI.lower = round(ci.l.ch, 3),
+   CI.upper = round(ci.u.ch, 3)
+ )
```

```
> colnames(or.ci.ch) <- c("Intercept.L", "Age2.L", "Age3.L", "Age4.L",
+                         "Age5.L","Age6.L","Intercept.U","Age2.U", "Age3.U", "Age4.U",
+                         "Age5.U","Age6.U")

> # Check class distribution per age
>
> tb.byage.ch <- child.lik %>%
+ count(age, class) %>%
+   pivot_wider(names_from = class, values_from = n, values_fill = 0)

> # LCA, Adults ------------------------------------------------------------
>
> adult.lik <- adult.lik.back

> # Predictors (motives)
> adult.lik.y <- as.matrix(adult.lik %>%
+                            dplyr::select(-mins,-age,-gender,-eth))

> # Spec formula for LCA
> lca.f.adult <- adult.lik.y ~ gender + eth

> # LCAE.ad <- poLCA(lca.f.adult, data = adult.lik, nclass = 2:7)
> # save(LCAE.ad, file="LCAE.ad.RData")
> load(file="LCAE.ad.RData")

> # bootstrapped Vuong-Lo-Mendell-Rubin likelihood ratio test
> # blrt.ad <- poLCA.blrt(LCAE.ad, quick = T,nreps = 10)
> # save(blrt.ad,file="blrt.ad.RData")
> # load(file="blrt.ad.RData")
>
>
> # Take relevant stats
> ad.lca.output <- LCAE.ad$output %>% dplyr::select(nclass,llike,AIC,BIC,
+                                                   Rel.Entropy,LMR,p)

> ad.lca.output

> # adeck posterior and boxplots
> # for(k in 2:5){
> #
> #   adult.lik$post <- apply(LCAE.ad$LCA[[k]]$posterior, 1, max)
> #   adult.lik$class <- LCAE.ad$LCA[[k]]$predclass
> #
> #   print(
> #     ggplot(adult.lik, aes(x = post, fill = factor(class))) +
> #       geom_histogram(binwidth = 0.05, alpha = 0.7, position = "identity") +
> #       labs(x = "Max Posterior Probability", y = "Count", fill = "Class",
> #            title = paste0(k+1," Classes, Adults")) +
> #       theme_minimal()
> #   )
> #
> #   print(ggplot(adult.lik, aes(x = factor(class), y = post)) +
> #          geom_boxplot(fill = "skyblue") +
```

```
> #           labs(x = "Class", y = "Max Posterior Probability",
> #                title = paste0(k+1," Classes, Adults")) +
> #           theme_minimal()
> #   )
> # }
>
> # Compare class average posteriors and class prop
>
> post6.ad <- LCAE.ad$LCA[[5]]$posterior

> class6.ad <- apply(post6.ad, 1, which.max)

> class.size6.ad <- prop.table(table(class6.ad))

> ave.pp6.ad <- sapply(1:ncol(post6.ad), function(k) {
+   inds <- which(class6.ad == k)
+   mean(post6.ad[inds, k])
+ })

> ave.pp6.ad

> post5.ad <- LCAE.ad$LCA[[4]]$posterior

> class5.ad <- apply(post5.ad, 1, which.max)

> class.size5.ad <- prop.table(table(class5.ad))

> ave.pp5.ad <- sapply(1:ncol(post5.ad), function(k) {
+   inds <- which(class5.ad == k)
+   mean(post5.ad[inds, k])
+ })

> ave.pp5.ad

> post4.ad <- LCAE.ad$LCA[[3]]$posterior

> class4.ad <- apply(post4.ad, 1, which.max)

> class.size4.ad <- prop.table(table(class4.ad))

> ave.pp4.ad <- sapply(1:ncol(post4.ad), function(k) {
+   inds <- which(class4.ad == k)
+   mean(post4.ad[inds, k])
+ })

> ave.pp4.ad

> post3.ad <- LCAE.ad$LCA[[2]]$posterior

> class3.ad <- apply(post3.ad, 1, which.max)

> class.size3.ad <- prop.table(table(class3.ad))

> ave.pp3.ad <- sapply(1:ncol(post3.ad), function(k) {
```

```
+   inds <- which(class3.ad == k)
+   mean(post3.ad[inds, k])
+ })

> ave.pp3.ad

> # BEST CLASS decided
> # 3 classes is best
> lca.best.ad <- LCAE.ad$LCA[[2]]

> adult.lik$class <- lca.best.ad$predclass

> adult.lik$post <- apply(lca.best.ad$posterior, 1, max)

> # Calculate median minutes
> n.classes <- 3

> wmed.ad <- numeric(n.classes)

> wq25.ad <- numeric(n.classes)

> wq75.ad <- numeric(n.classes)

> for (k in 1:n.classes) {
+
+   q <- wtd.quantile(adult.lik$mins,
+                     weights = lca.best.ad$posterior[,k],
+                     probs = c(0.25, 0.5, 0.75))
+   wq25.ad[k] <- q[1]
+   wmed.ad[k] <- q[2]
+   wq75.ad[k] <- q[3]
+ }


> # Regressions
> adult.lik$age <- adult.lik.back$age

> adult.lik$class <- relevel(factor(adult.lik$class), ref = "1")

> adult.lik$age <- relevel(factor(adult.lik$age), ref = "1")

> fit.ad <- multinom(class ~ age,
+                    data = adult.lik)
# weights:  21 (12 variable)
initial  value 127458.800507
iter  10 value 108640.273108
iter  20 value 100457.045377
iter  20 value 100457.044488
iter  20 value 100457.044435
final  value 100457.044435
converged

> # odds ratio
> or.ad <- exp(coef(fit.ad))
```

```
> or.ad

> sum.fit.ad <- summary(fit.ad)

> se.ad <- sum.fit.ad$standard.errors

> # Coefficients
> coefs.ad <- coef(fit.ad)

> # 95% CI for odds ratios
> ci.l.ad <- exp(coefs.ad - 1.96 * se.ad)

> ci.u.ad <- exp(coefs.ad + 1.96 * se.ad)

> # Combine into a table
> or.ci.ad <- data.frame(
+   CI.lower = round(ci.l.ad, 3),
+   CI.upper = round(ci.u.ad, 3)
+ )

> colnames(or.ci.ad) <- c("Intercept.L", "Age2.L", "Age3.L", "Age4.L",
+                         "Age5.L","Age6.L","Intercept.U","Age2.U", "Age3.U", "Age4.U",
+                         "Age5.U","Age6.U")

> # adeck class distribution per age
>
> tb.byage.ad <- adult.lik %>%
+   count(age, class) %>%
+   pivot_wider(names_from = class, values_from = n, values_fill = 0)
```

Appendix G - R Code (Visualization)

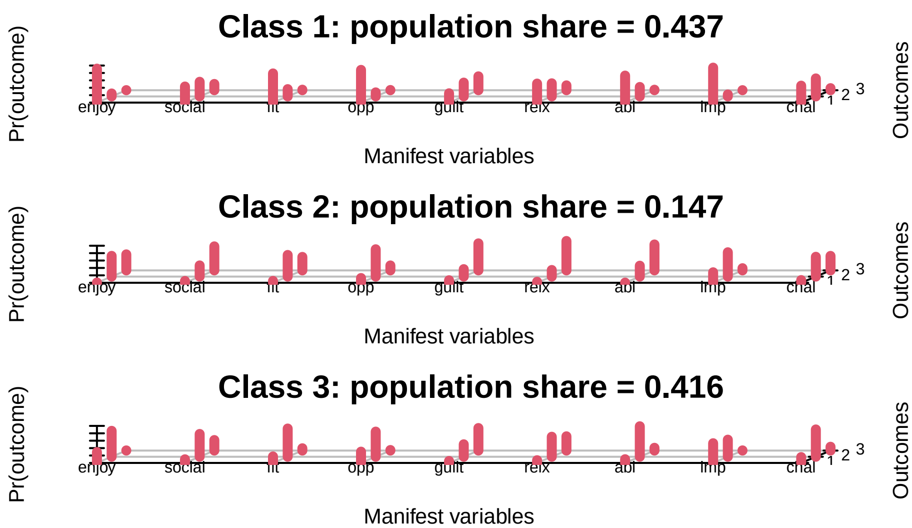
```
> set.seed(2025)

> library(tidyverse)

> library(ggplot2)

> library(poLCA)

> library(poLCAExtra)

> library(scales)

> library(ggthemes)

> options(digits = 4)

> # Descriptive ------------------------------------------------------------
> child.summary.bi <- data.frame(colMeans(
+   child.bi[, setdiff(names(child.bi),
+                      c("gender", "eth", "age", "mins"))], na.rm = TRUE))

> colnames(child.summary.bi) <- ("Proportion")

> adult.summary.bi <- data.frame(colMeans(
+   adult.bi[, setdiff(names(adult.bi),
+                      c("gender", "eth", "age","mins"))], na.rm = TRUE))

> colnames(adult.summary.bi) <- ("Proportion")

> cor.ie <- cor(adult.lik.back0 %>% dplyr::select(-gender,-eth), method = "pearson")[6,1]

> cor.if <- cor(adult.lik.back0 %>% dplyr::select(-gender,-eth), method = "pearson")[6,3]

> cor.imp <- data.frame("Imp,Enjoy"=cor.ie, "Imp,Fit"=cor.if)

> # get summary of all motives
> adult.summary <- adult.var %>%
+   mutate(mins = DUR_HVY_CAPPED_SPORTCOUNT_A01+
+                   DUR_MOD_CAPPED_SPORTCOUNT_A01) %>%
+   dplyr::select(
+     Enjoyment = Motiva_POP,
+     Social = motivex2c,
+     Fitness = motivex2a,
+     Guilt = motivc_POP,
+     Opportunity = READYOP1_POP,
+     Importance = motivb_POP,
+     Challenge = motivex2d,
+     Relaxation = motivex2b,
+     Minutes.Exercised = mins
+   ) %>%
+   summarise(
```

```
+     across(everything(),
+            list(
+              Mean = ~mean(.x[.x > 0], na.rm = TRUE),
+              Median = ~median(.x[.x > 0], na.rm = TRUE),
+              SD = ~sd(.x[.x > 0], na.rm = TRUE),
+              PercentNA = ~mean(.x < 0, na.rm = TRUE) * 100
+            ),
+            .names = "{.col}_{.fn}"
+     )
+   ) %>%
+   pivot_longer(everything(), names_to = c("Variable", "Stat"), names_sep = "_") %>%
+   pivot_wider(names_from = Stat, values_from = value)

> child.summary <- child.var %>%
+   dplyr::select(
+     Enjoyment = PL_Enjoy_bc_ans,
+     Social = MO_Fun_c,
+     Fitness = MO_Fit_c,
+     Opportunity = MO_Opp_c,
+     Guilt = MO_Guilt_c,
+     Importance = PL_GdMe_bc_ans,
+     Challenge = Try_bc,
+     Relaxation = MO_Relax_c
+   ) %>%
+   summarise(
+     across(everything(),
+            list(
+              Mean = ~mean(.x[.x > 0 & .x <= 4], na.rm = TRUE),
+              Median = ~median(.x[.x > 0 & .x <= 4], na.rm = TRUE),
+              SD = ~sd(.x[.x > 0 & .x <= 4], na.rm = TRUE),
+              PercentNA = ~mean(.x < 0 | .x > 4, na.rm = TRUE) * 100
+            ),
+            .names = "{.col}_{.fn}"
+     )
+   ) %>%
+   pivot_longer(everything(), names_to = c("Variable", "Stat"), names_sep = "_") %>%
+   pivot_wider(names_from = Stat, values_from = value)

> c.mins <- child.var %>%
+   summarise(Variable = "Minutes.Exercised",
+             Mean = mean(mins_modplus_outschool_Week_ALL[mins_modplus_outschool_Week_ALL > 0 ], na.rm =
+             Median = median(mins_modplus_outschool_Week_ALL[mins_modplus_outschool_Week_ALL > 0], na.r
+             SD = sd(mins_modplus_outschool_Week_ALL[mins_modplus_outschool_Week_ALL > 0], na.rm = TRUE
+             PercentNA = mean(mins_modplus_outschool_Week_ALL < 0, na.rm = TRUE) * 100)

> child.summary <- rbind(child.summary, c.mins)

> # get demographic overview (gender, edu, eth, mins)
> # adult
> #
> # # Disability
> # gg.ad.dsbl <- ggplot(adult.var, aes(x = as.factor(Disab2_POP))) +
> #   geom_bar() +
> #   labs(x = "Disability") +
```

```
> #   theme_clean()
>
> # Gender
> adult.lik$gender <- factor(adult.lik$gender, levels = c(1, 2),
+                            labels = c("Male", "Female"))

> gg.ad.gend <- ggplot(adult.lik, aes(x = as.factor(gender))) +
+   geom_bar() +
+   labs(x = "Gender") +
+   theme_clean()

> # Age
> adult.lik$age <- factor(adult.lik$age, levels = c(1,2,3,4,5,6),
+                         labels = c("16-34", "35-44", "45-54",
+                                    "55-64", "65-74", "75+"))

> gg.ad.age <-ggplot(adult.lik, aes(x = as.factor(age))) +
+   geom_bar() +
+   labs(x = "Age Group") +
+   theme_clean()

> # Ethnicity
> adult.lik$eth <- factor(adult.lik$eth, levels = c(1, 2),
+                         labels = c("White British", "Other"))

> gg.ad.eth <- ggplot(adult.lik, aes(x = as.factor(eth))) +
+   geom_bar() +
+   labs(x = "Ethnicity") +
+   theme_clean()

> # Education
> # gg.ad.edu <- ggplot(adult.lik, aes(x = as.factor(edu))) +
> #   geom_bar() +
> #   labs(x = "Education") +
> #   theme_clean()
>
> # YOuths
> #
> # Disability
> # gg.ch.dsbl <- ggplot(child.var, aes(x = as.factor(Disab_All_POP))) +
> #   geom_bar() +
> #   labs(x = "Disability") +
> #   theme_clean()
>
> # Gender
> child.lik$gender <- factor(child.lik$gender, levels = c(1, 2),
+                            labels = c("Male", "Female"))

> gg.ch.gend <- ggplot(child.lik, aes(x = as.factor(gender))) +
+   geom_bar() +
+   labs(x = "Gender") +
+   theme_clean()

> # Age
```

```
> child.lik$age <- factor(child.lik$age, levels = c(1,2,3,4,5,6),
+                         labels = c(11,12,13,14,15,16))

> gg.ch.age <- ggplot(child.lik, aes(x = as.factor(age))) +
+   geom_bar() +
+   labs(x = "Age") +
+   theme_clean()

> # Ethnicity
> child.lik$eth <- factor(child.lik$eth, levels = c(1, 2),
+                         labels = c("White British", "Other"))

> gg.ch.eth <- ggplot(child.lik, aes(x = as.factor(eth))) +
+   geom_bar() +
+   labs(x = "Ethnicity") +
+   theme_clean()

> # SEM -------------------------------------------------------------------
> # # slope_youth - slope_adult, pooled sd
> # cohen <- rbind(cohen.enj, cohen.soc, cohen.fit,cohen.glt,cohen.opp)
> # rownames(cohen) <- c("Enjoy", "Social", "Fit","Guilt","Opp")
> # colnames(cohen) <- c("Std Eff", "Min")
> # cohen
> # LCA Youths--------------------------------------------------------------
>
> # elbow plot
> gg.elbow.ch <- ggplot(ch.lca.output, aes(x = nclass)) +
+   geom_line(aes(y = BIC), color = "blue") +
+   geom_point(aes(y = BIC), color = "blue") +
+   geom_line(aes(y = AIC), color = "red") +
+   geom_point(aes(y = AIC), color = "red") +
+   labs(y = "Information Criterion", x = "Number of Classes",
+        title = "Elbow Plot, Youths",
+        caption = "Blue = BIC, Red = AIC") +
+   theme_clean()

> gg.elbow.ch

> gg.llik.ch <- ggplot(ch.lca.output, aes(x = nclass)) +
+   geom_line(aes(y = llike), color = "blue") +
+   geom_point(aes(y = llike), color = "blue") +
+   labs(y = "Log-Likelihood", x = "Number of Classes",
+        title = "Log-Likelihood, Youths") +
+   theme_clean()

> gg.llik.ch

> #
> # # Max posterior
> # gg.post.his.ch <- ggplot(child.lik, aes(x = post, fill = factor(class))) +
> #   geom_histogram(binwidth = 0.05, alpha = 0.7, position = "identity") +
> #   labs(x = "Max Posterior Probability", y = "Count", fill = "Class",
> #        title = paste0(k," Classes, Youths")) +
> #   theme_clean()
```

```
> # gg.post.his.ch
> #
> # # Boxplot
> # gg.post.box.ch <- ggplot(child.lik, aes(x = factor(class), y = post)) +
> #   geom_boxplot(fill = "skyblue") +
> #   labs(x = "Class", y = "Max Posterior Probability",
> #        title = paste0(k," Classes, Youths")) +
> #   theme_clean()
>
>
> # class,size/proportion, average pp,entropy
>
> tb.class3.ch <- data.frame(
+   Class = 1:ncol(post3.ch),
+   Proportion = as.numeric(class.size3.ch),
+   Avg_Posterior = round(ave.pp3.ch, 3)
+ )

> tb.class3.ch

> tb.class4.ch <- data.frame(
+   Class = 1:ncol(post4.ch),
+   Proportion = as.numeric(class.size4.ch),
+   Avg_Posterior = round(ave.pp4.ch, 3)
+ )

> # Weighted minutes, youths
> mins.child <- data.frame(
+   Class = 1:n.classes,
+   Weighted.Median = wmed.ch,
+   Weighted.Q25 = wq25.ch,
+   Weighted.Q75 = wq75.ch
+ )

> mins.child

> gg.mins.ch <- ggplot(mins.child, aes(x = factor(Class), y = Weighted.Median)) +
+   geom_point(size = 3, color = "blue") +                 # median as a point
+   geom_errorbar(aes(ymin = Weighted.Q25, ymax = Weighted.Q75),
+                 width = 0.2, color = "darkblue") +      # IQR as error bars
+   labs(x = "Class", y = "Minutes (Weighted Median ± IQR)",
+        title = "Weighted Median and IQR per Class") +
+   theme_clean()

> gg.mins.ch

> gg.med.ch <- ggplot(mins.child, aes(x = Class, y = Weighted.Median)) +
+   geom_col() +
+   labs(x = "Latent Class", y = "Probability-Weighted Median Minutes")

> gg.med.ch

> # Predictor plot
> plot(LCAE.ch, nclass = 2)
```

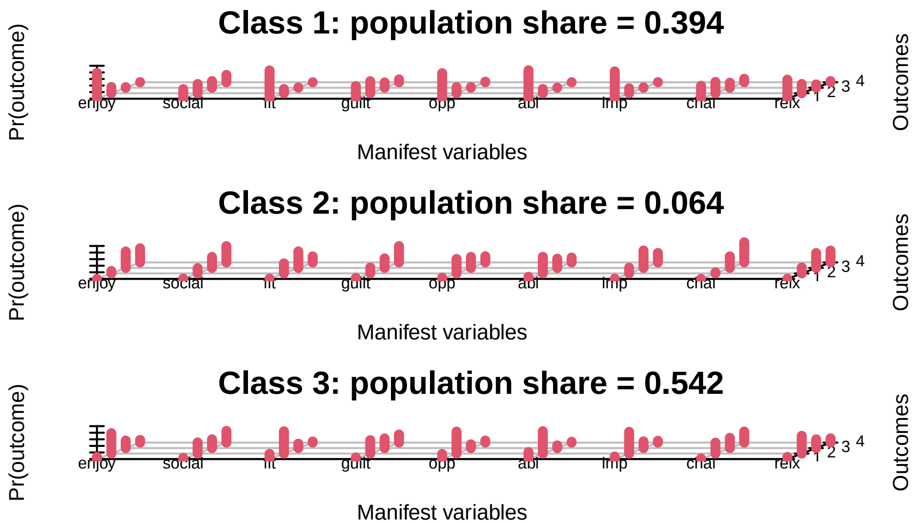



```
> # Bootstrap Vuong-Lo-Mendell-Rubin Likelihood Ratio Test
> or.ch

> # Appendix
> or.ci.ch

> # Include actual coeffs in appendix
> lca.best.ch$probs

> tb.byage.ch

> gg.byage.ch <- child.lik %>%
+   dplyr::count(age, class) %>%
+   group_by(age) %>%
+   mutate(prop = n / sum(n)) %>%
+   ggplot(aes(x = factor(age), y = prop, fill = factor(class))) +
+   geom_col() +
+   labs(x = "Age group", y = "Proportion", fill = "Class") +
+   scale_y_continuous(labels = scales::percent_format()) +
+   theme_clean()

> gg.byage.ch

> vars.ch <- setdiff(names(child.lik), c("age","mins","post","class",
+                                        "gender","eth","edu"))

> child.lik_long <- child.lik %>%
+   pivot_longer(cols = all_of(vars.ch), names_to = "variable", values_to = "score") %>%
+   count(age, variable, score) %>%
+   group_by(age, variable) %>%
+   mutate(prop = n / sum(n))

> gg.vars.ch <- ggplot(child.lik_long, aes(x = factor(age), y = prop, fill = factor(score))) +
+   geom_col() +
```

```
+   facet_wrap(~variable, nrow = 3, ncol = 3) +
+   labs(x = "Age group", y = "Proportion", fill = "Score") +
+   scale_y_continuous(labels = percent_format()) +
+   theme_clean() +
+   theme(legend.position = "bottom", axis.text.y = element_text(size = 6))

> # LCA Adults -------------------------------------------------------------
>
>
> # elbow plot
> gg.elbow.ad <- ggplot(ad.lca.output, aes(x = nclass)) +
+   geom_line(aes(y = BIC), color = "blue") +
+   geom_point(aes(y = BIC), color = "blue") +
+   geom_line(aes(y = AIC), color = "red") +
+   geom_point(aes(y = AIC), color = "red") +
+   labs(y = "Information Criterion", x = "Number of Classes",
+        title = "Elbow Plot, Adults",
+        caption = "Blue = BIC, Red = AIC") +
+   theme_clean()

> gg.elbow.ad

> gg.llik.ad <- ggplot(ad.lca.output, aes(x = nclass)) +
+   geom_line(aes(y = llike), color = "blue") +
+   geom_point(aes(y = llike), color = "blue") +
+   labs(y = "Log-Likelihood", x = "Number of Classes",
+        title = "Log-Likelihood, Adults") +
+   theme_clean()

> gg.llik.ad

> # # Max posterior
> # gg.post.his.ad <- ggplot(adult.lik, aes(x = post, fill = factor(class))) +
> #   geom_histogram(binwidth = 0.05, alpha = 0.7, position = "identity") +
> #   labs(x = "Max Posterior Probability", y = "Count", fill = "Class",
> #        title = paste0(k," Classes, Adults")) +
> #   theme_clean()
> # gg.post.his.ad
> #
> # # Boxplot
> # gg.post.box.ad <- ggplot(adult.lik, aes(x = factor(class), y = post)) +
> #   geom_boxplot(fill = "skyblue") +
> #   labs(x = "Class", y = "Max Posterior Probability",
> #        title = paste0(k," Classes, Adults")) +
> #   theme_clean()
>
>
> # class,size/proportion, average pp,entropy
>
> tb.class3.ad <- data.frame(
+   Class = 1:ncol(post3.ad),
+   Proportion = as.numeric(class.size3.ad),
+   Avg_Posterior = round(ave.pp3.ad, 3)
+ )
```

```
> tb.class3.ad

> tb.class4.ad <- data.frame(
+   Class = 1:ncol(post4.ad),
+   Proportion = as.numeric(class.size4.ad),
+   Avg_Posterior = round(ave.pp4.ad, 4)
+ )

> tb.class4.ad

> tb.class5.ad <- data.frame(
+   Class = 1:ncol(post5.ad),
+   Proportion = as.numeric(class.size5.ad),
+   Avg_Posterior = round(ave.pp5.ad, 5)
+ )

> tb.class5.ad

> tb.class6.ad <- data.frame(
+   Class = 1:ncol(post6.ad),
+   Proportion = as.numeric(class.size6.ad),
+   Avg_Posterior = round(ave.pp6.ad, 6)
+ )

> tb.class6.ad

> mins.adult <- data.frame(
+   Class = 1:n.classes,
+   Weighted.Median = wmed.ad,
+   Weighted.Q25 = wq25.ad,
+   Weighted.Q75 = wq75.ad
+ )

> mins.adult

> gg.mins.ad <- ggplot(mins.adult, aes(x = factor(Class), y = Weighted.Median)) +
+   geom_point(size = 3, color = "blue") +                 # median as a point
+   geom_errorbar(aes(ymin = Weighted.Q25, ymax = Weighted.Q75),
+                 width = 0.2, color = "darkblue") +      # IQR as error bars
+   labs(x = "Class", y = "Minutes (Weighted Median ± IQR)",
+        title = "Weighted Median and IQR per Class") +
+   theme_clean()

> gg.mins.ad

> #
> # # Weighted minutes, youths
> # gg.med.ad <- ggplot(mins.adult, aes(x = Class, y = Weighted.Median)) +
> #   geom_col() +
> #   labs(x = "Latent Class", y = "Probability-Weighted Median Minutes")
>
>
> # Predictor plot
```

```
> plot(LCAE.ad, nclass = 2)
```




```
> # plot(LCAE.ad, nclass = 3)
>
> # Bootstrap Vuong-Lo-Mendell-Rubin Likelihood Ratio Test
> # 100 reps
> # blrt.ad
> or.ad

> or.ci.ad

> # Include actual coeffs in appendix
> lca.best.ad$probs

> tb.byage.ad

> gg.byage.ad <- adult.lik %>%
+   dplyr::count(age, class) %>%
+   group_by(age) %>%
+   mutate(prop = n / sum(n)) %>%
+   ggplot(aes(x = factor(age), y = prop, fill = factor(class))) +
+   geom_col() +
+   labs(x = "Age group", y = "Proportion", fill = "Class") +
+   scale_y_continuous(labels = scales::percent_format()) +
+   theme_clean()

> gg.byage.ad

> vars.ad <- setdiff(names(adult.lik), c("age","mins","post","class",
+                                        "gender","eth","edu"))

> adult.lik_long <- adult.lik %>%
+   pivot_longer(cols = all_of(vars.ad), names_to = "variable", values_to = "score") %>%
```

```
+   count(age, variable, score) %>%
+   group_by(age, variable) %>%
+   mutate(prop = n / sum(n))

> gg.vars.ad <- ggplot(adult.lik_long, aes(x = factor(age), y = prop, fill = factor(score))) +
+   geom_col() +
+   facet_wrap(~variable, nrow = 3, ncol = 3) +
+   labs(x = "Age group", y = "Proportion", fill = "Score") +
+   scale_y_continuous(labels = percent_format()) +
+   theme_clean() +
+   theme(legend.position = "bottom", axis.text.y = element_text(size = 6),
+         axis.text.x = element_text(size = 6))

> gg.vars.ad

> # Survey questions
> # youths
> vc1 <- c('enjoy','social','fit','opp','guilt','imp','chal','abil','relx')

> vc2 <- c('PL_Enjoy_bc_ans','MO_Fun_c','MO_Fit_c','MO_Opp_c','MO_Guilt_c',
+          'PL_GdMe_bc_ans','Try_bc','PL_Conf_bc_ans','MO_Relax_c')

> vc3 <- c("I enjoy taking part in exercise and sports.",
+          "I exercise socially for fun with friends.",
+          "I exercise to stay fit and healthy.",
+          "I feel that I have the opportunity to be physically active.",
+          "I feel guilty when I don't exercise.",
+          "I understand why exercise and sports are good for me.",
+          "If I find something difficult, I keep trying until I can do it.",
+          "I feel confident when I exercise and play sports.",
+          "I exercise to help me relax and worry less about things ."
+          )

> vc <- data.frame(vc1,vc2,vc3)

> colnames(vc) <- c("Variable", "Origianl Variable Name", "Survey Question")

> va1 <- c('enjoy','social','fit','opp','guilt','imp','chal','abil','relx')

> va2 <- c('Motiva_POP','motivex2c','motivex2a','READYOP1_POP','motivc_POP',
+          'motivb_POP','motivex2d','READYAB1_POP','motivex2b')

> va3 <- c("Motivation for sport/exercise: I find sport/exercise enjoyable and satisfying.",
+          "I exercise socially for fun with friends.",
+          "I exercise to stay fit and healthy.",
+          "Readiness for activity: Opportunity,",
+          "Motivation for sport/exercise: I feel guilty when I don't do sport/exercise.",
+          "Motivation for sport/exercise: It's important to me to do sport/exercise regularly.",
+          "I exercise to challenge myself (either against myself or others).",
+          "Readiness for activity: Ability.",
+          "I exercise to help me relax and worry less about things."
+          )

> va <- data.frame(va1,va2,va3)
```

```
> colnames(va) <- c("Variable", "Origianl Variable Name", "Survey Question")
```

Appendix H - R code (R Markdown)

```
source(file="data.R")
source(file="SEM.R")
source(file="LCA.R")
source(file="Visualization.R")
gg.ad.age
gg.ad.gend
gg.ad.eth
opts <- options(knitr.kable.NA = '')
kable(list(adult.summary.bi),align='c',booktabs = T) %>%
  kable_styling(position = 'center', font_size = 10,
                latex_options = c('striped',
                                  'hold_position'))

gg.vars.ad


gg.ch.age
gg.ch.gend
gg.ch.eth

opts <- options(knitr.kable.NA = '')
kable(list(child.summary.bi),align='c',booktabs = T) %>%
  kable_styling(position = 'center', font_size = 10,
                latex_options = c('striped',
                                  'hold_position'))

gg.vars.ch

opts <- options(knitr.kable.NA = '')
kable(list(slopes.diff),align='c',booktabs = T) %>%
  kable_styling(position = 'center', font_size = 10,
                latex_options = c('striped',
                                  'hold_position'))

gg.elbow.ad
gg.llik.ad


plot(LCAE.ad, nclass = 2)


gg.mins.ad


gg.byage.ad

opts <- options(knitr.kable.NA = '')
kable(list(or.ad),align='c',booktabs = T) %>%
  kable_styling(position = 'center', font_size = 10,
                latex_options = c('striped',
                                  'hold_position'))
```

```r
gg.elbow.ch
gg.llik.ch


plot(LCAE.ch, nclass = 2)


gg.mins.ch


gg.byage.ch

opts <- options(knitr.kable.NA = '')
kable(list(or.ch),align='c',booktabs = T) %>%
  kable_styling(position = 'center', font_size = 10,
                latex_options = c('striped',
                                  'hold_position'))
opts <- options(knitr.kable.NA = '')
kable(list(va),align='c',booktabs = T) %>%
  kable_styling(position = 'center', font_size = 10,
                latex_options = c('striped',
                                  'hold_position'))
opts <- options(knitr.kable.NA = '')
kable(list(vc),align='c',booktabs = T) %>%
  kable_styling(position = 'center', font_size = 10,
                latex_options = c('striped',
                                  'hold_position'))
opts <- options(knitr.kable.NA = '')
kable(list(adult.summary),align='c',booktabs = T) %>%
  kable_styling(position = 'center', font_size = 10,
                latex_options = c('striped',
                                  'hold_position'))
opts <- options(knitr.kable.NA = '')
kable(list(child.summary),align='c',booktabs = T) %>%
  kable_styling(position = 'center', font_size = 10,
                latex_options = c('striped',
                                  'hold_position'))
source("data.R", echo = T, print.eval = F,
       max.deparse.length=Inf, keep.source=T)
source("SEM.R", echo = T, print.eval = F,
       max.deparse.length=Inf, keep.source=T)
source("LCA.R", echo = T, print.eval = F,
       max.deparse.length=Inf, keep.source=T)
source("Visualization.R", echo = T, print.eval = F,
       max.deparse.length=Inf, keep.source=T)
```