Motivational Transitions in Physical Activity from Youth to Adulthood: Insights from Multigroup SEM and Latent Class Approaches

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Introduction

Physical inactivity remains a pressing global public health concern, with nearly 1.8 billion individuals failing to meet recommended levels of physical activity (PA) (World Health Organization, 2024), representing a 9% increase over the past two decades (Mitchell, 2019; Strain *et al.*, 2024). Insufficient PA contributes not only to physiological decline but also to a broad spectrum of chronic diseases, including cardiovascular conditions, diabetes, and certain cancers, as well as mental health issues such as depression and anxiety (Anderson & Shivakumar, 2013; Booth *et al.*, 2012; White *et al.*, 2024). Given this multifaceted impact, understanding the drivers of PA behaviour has become a major public health and behavioural science priority. Among these drivers, motivation consistently emerges as one of the most robust predictors of sustained participation (Daley & Duda, 2006; Duncan *et al.*, 2010).

Motivation is central to explaining why individuals initiate, persist, or disengage from PA, yet it operates within complex social and developmental contexts. Psychological frameworks such as Self-Determination Theory (SDT) and the Theory of Planned Behaviour (TPB) have been foundational in conceptualising these motivational processes. SDT highlights the role of intrinsic motivation and the satisfaction of autonomy, competence, and relatedness needs in promoting long-term adherence (Deci & Ryan, 2008; Brooks *et al.*, 2017). TPB, in contrast, situates motivation within broader social-cognitive structures, linking behavioural intentions to attitudes, subjective norms, and perceived behavioural control (Ajzen, 1991). Yet despite extensive research using these models, most studies have examined age-related motivational differences within either youth or adult populations in isolation.

As a result, it remains unclear whether age shapes the strength of specific exercise motives or the configuration of underlying motivational profiles across the transition from adolescence to adulthood, a period marked by increasing autonomy and changing social and environmental contexts. Exploring this gap is essential can guide the design of developmentally tailored interventions and policy initiatives. This dissertation adopts both variable- and person-centred approaches. Specifically, two research questions are addressed:

1. Do perceived exercise motives influence physical activity differently in youths and adults?
2. Does age influence motivational profiles of physical activity differently in youths and adults?

To answer these questions, a multigroup structural equation modelling (SEM) approach was first applied to test whether the relationships between specific motives and physical activity differ across developmental stages (adults vs youths). While examining individual motives provides insight into which factors most strongly predict physical activity at different ages, prior research has noted as a limitation that such analyses assume motives operate independently and linearly (Brunet & Sabiston, 2011). Motivation, however, is multidimensional, and individuals often hold combinations of intrinsic and extrinsic reasons for exercising that interact in complex ways. To capture these naturally occurring patterns and obviate the need to assume independence and linearity, latent class analysis (LCA) was then employed to identify distinct motivational profiles within youths and adults separately, enabling examination of age-related trends in profile membership. Using comparable variables and data structures across both groups allows for a direct assessment of whether similar age effects are observed on the overall pattern of physical activity motivation across developmental stages.

Literature Review

Self-Determination Theory

SDT is a popular framework that has gained popularity in the past two decades. Developed by Ryan & Deci (2000), it emphasizes the degree to which behaviour is self-determined. Motivation is classified on the autonomy continuum as amotivation, extrinsic, and intrinsic. WIthin extrinsic motivation, there exist external, introjected, identified, and integrated regulation, with internalization increasing progressively from none to fully intrinsic under the minitheory Organismic Integration Theory within SDT (Standage, 2019).

External regulation occurs when actions are guided by outside influences, such as rewards or punishments. Introjected regulation reflects behaviour driven by internal pressures, such as guilt. In identified regulation, individuals willingly engage in an activity because they recognize its personal value or the benefits it provides. Integrated regulation aligns behaviour is completely aligned with one's identity and broader goals (Ryan & Deci, 2017). Intrinsic motivation, by contrast, arises from interest, enjoyment, or inherent satisfaction in the activity itself. While evidence on the relationship between PA and specific constructs is mixed, prior studies indicate that stronger intrinsic motives are positively associated with exercise participation, lower dropout rates, and improved physical and psychological wellbeing.(Ng *et al.*, 2012; Teixeira *et al.*, 2012).

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 PA adherence (Trigueros *et al.*, 2019). While this may be due to individual differences in baseline motivation or contextual factors, past research often overlooked the role of external constraints and structural factors, such as socioeconomic status. These external factors may interact with psychological needs in complex ways that SDT does not fully address.

Theory of Planned Behaviour

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, and PBC represents the perceived performance ease. These factors interact to shape intention, which in turn predicts behaviour. In the context of PA, 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 (Neipp, 2013; Wang, 2015).

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 PBC, 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. However, the theory's predictive performance varies by gender, and the role of TPB variables in predicting PA intentions is inconsistent. While perceived behavioural control (PBC) has often been found to predict both intention and behaviour (Ajzen, 1991; Godin & Kok, 1996), other studies have identified attitude as the strongest predictor, with subjective norm generally showing limited influence. However, exceptions exist, such as its positive association with behaviour among professional footballers (Moreno-Murcia *et al.*, 2013). More recently, Kim *et al.* (2019) suggested that previous weak effects of subjective norms may have been a result of neglect of subjects' normative referents and inclination to comply. Nevertheless, there exists consistent evidence for the relationship between PA and TPB variables in general (Hagger *et al.*, 2002).

Age-Related Differences

Intrinsic motivation tends to decline with age regardless of developmental stage (Brunet & Sabiston, 2011; Dishman *et al.*, 2018; de Maio Nascimento *et al.*, 2023), suggesting that the factors driving engagement shift across the lifespan.

Among adults, aging appears to be associated with a recalibration of goals toward health maintenance and psychological well-being, rather than engagement driven primarily by enjoyment or self-affirmation. Older adults consistently report lower intrinsic motivation and introjected regulation, which corresponds with reduced PA levels compared to younger adults (Brunet & Sabiston, 2011). In contrast, middle-aged adults are more likely to exercise for health, fitness, and psychological well-being, suggesting a shift toward more outcome-oriented motives with age (Brunet & Sabiston, 2011; de Maio Nascimento *et al.*, 2023). Notably, some motivators, such as relaxation and stress relief, remain relatively stable across age groups, indicating that these factors may serve as universal supports for PA adherence and associated psychological benefits (de Maio Nascimento *et al.*, 2023; Vuckovic & Duric, 2024; Kilgour *et al.*, 2005). Contextual factors, including access to facilities and opportunities for participation, influence PA levels consistently across the adult lifespan (Brunet & Sabiston, 2011; Dishman *et al.*, 2018), highlighting the importance of structural supports alongside motivational processes.

In youths, intrinsic motivation, enjoyment, and social support emerge as key drivers of habitual PA. Evidence indicates that adolescents who sustain high intrinsic motivation and personally meaningful goals, particularly those focused on enjoyment, maintain higher activity levels over time (Sebire *et al.*, 2013). Conversely, declines in goals related to social recognition, competence, or appearance can undermine engagement (Dishman *et al.*, 2018). Cross-sectional studies further link higher motivation to adaptive outcomes such as social support (Heredia-León *et al.*, 2023), which is correlated with higher PA levels.

Although potential multicollinearity (Brunet & Sabiston, 2011), single-region recruitment and missing objective measures (de Maio Nascimento *et al.*, 2023), small subgroups and cultural specificity (Vuckovic & Duric, 2024), and limited demographic focus (Dishman *et al.*, 2018; Kilgour *et al.*, 2024) pose limitations, clear age-related differences emerge in the influence of specific motives. Enjoyment, social motives, and guilt appear particularly important for adolescents, whereas fitness, relaxation, and psychological well-being motives are more salient in adults. Comparing these patterns allows for distinguishing whether observed age differences reflect developmental shifts in the relevance of particular motives or simply variations in overall motivational intensity. Assessing the differential predictive power of these motives provides a more nuanced understanding of how motivation supports physical activity across the lifespan.

- 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 PA similarly across age groups.

Motivational Profiles

Motivational profiles provide a person-centred perspective on the heterogeneity of PA motives.

In adults, Ostendorf *et al.* (2021) identified three primary motivational profiles among individuals with overweight or obesity. Longitudinally, individuals in the high autonomous profile showed the least decline in moderate-to-vigorous PA during transitions from supervised to unsupervised exercise, suggesting that intrinsic and identified motivations support sustained engagement. Similarly, Nuss *et al.* (2023) identified four motivational profiles in Canadian adults, finding that combinations of controlled and autonomous motivation synergistically support activity.

In youths, Moreno-Murcia *et al.* (2013) identified 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 higher levels of PA. Heredia-León *et al.* (2023) similarly found that youths in higher motivation profiles demonstrated greater intention to be physically active and enjoyment in PE classes.

While prior studies clearly demonstrate heterogeneity in motivational profiles, several limitations constrain our understanding of developmental patterns. Most studies focus on either adults or youths, making cross-stage comparisons speculative. Differences in sample characteristics, such as health status, cultural context, or activity setting, may drive observed profile differences rather than age. In addition, methodological variations, such as the number and type of motivational items, statistical extraction methods, and criteria for class selection, introduce uncertainty in comparing profiles across studies.

These gaps suggest that examining age-related effects on motivational profiles using comparable variables and analytic approaches across youths and adults could yield a clearer picture of developmental trajectories. Such an approach allows for testing whether similar mechanisms underlie profile formation in different age groups and whether the influence of age is consistent. Investigating these patterns using comparable variables and data structures across youths and adults allows for a direct assessment, addressing this gap.

- H2(a). With increasing age, adults are more likely to belong to classes characterized by lower motivation.
- H2(b). With increasing age, youths are more likely to belong to classes characterized by lower 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 motive items 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. Due to small group sizes, ethnicity was coded as White British or Other. Observations with missing data or "I don't know" answers on any used item were likewise excluded. Additional descriptive statistics, including percentages of missing values are provided in Appendix C. Weekly minutes of moderate to vigorous PA were collected. For youths, out-of-school PA was used to capture voluntary activity, accounting for differences in curriculum requirements across grade levels. See Appendix B for full list of eligible exercises.

Motive and PA Items:

- 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 PA.
- Importance – recognizing the personal value or significance of PA.
- Challenge – persistence and enjoyment in pursuing difficult tasks.
- Minutes – total weekly minutes of moderate-to-vigorous PA.

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, to relax, or because one understands its benefits represent forms of identified regulation. Exercising socially for fun with friends can reflect either intrinsic or identified regulation. In contrast, exercising due to guilt is a classic example of introjected regulation. 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 was designed to provide a nationally representative picture of adult participation in PA 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 minimize seasonal and geographic bias. A total of 173,950 adults completed the survey. Weighting adjustments were applied to correct for differential response probabilities by Sport England. The questionnaire covered a broad range of topics, including PA frequency and duration, sports participation, volunteering, club membership, and motivational factors, along with demographic variables such as age, gender, education, and socio-economic status.

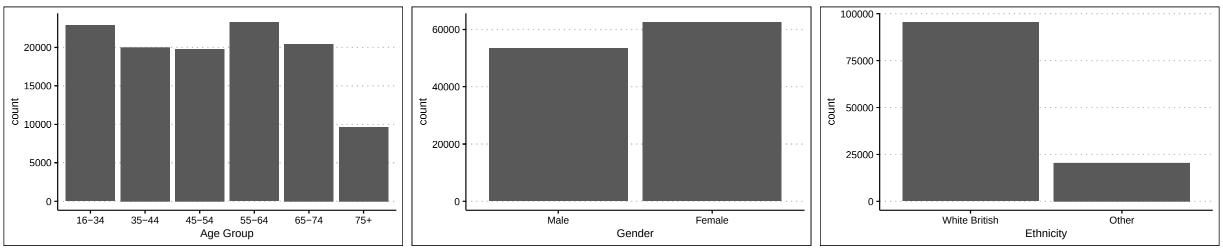

Figure 1: Distribution of age, gender, and ethnicity in adults.

Females comprised 54% of the sample, and White British participants accounted for 82%. Given no indication of meaningful differences between motivational profiles during preliminary analyses, the youngest and oldest age groups were collapsed with their neighbours due to small cell sizes at the extremes, forming six age brackets, namely 16–34, 35–44, 45–54, 55–64, 65–74, and 75+ (Figure 1). Collapsing these categories improved model stability without obscuring theoretically relevant distinctions. After adjustment, the age distribution remained moderately skewed but acceptable for analysis.

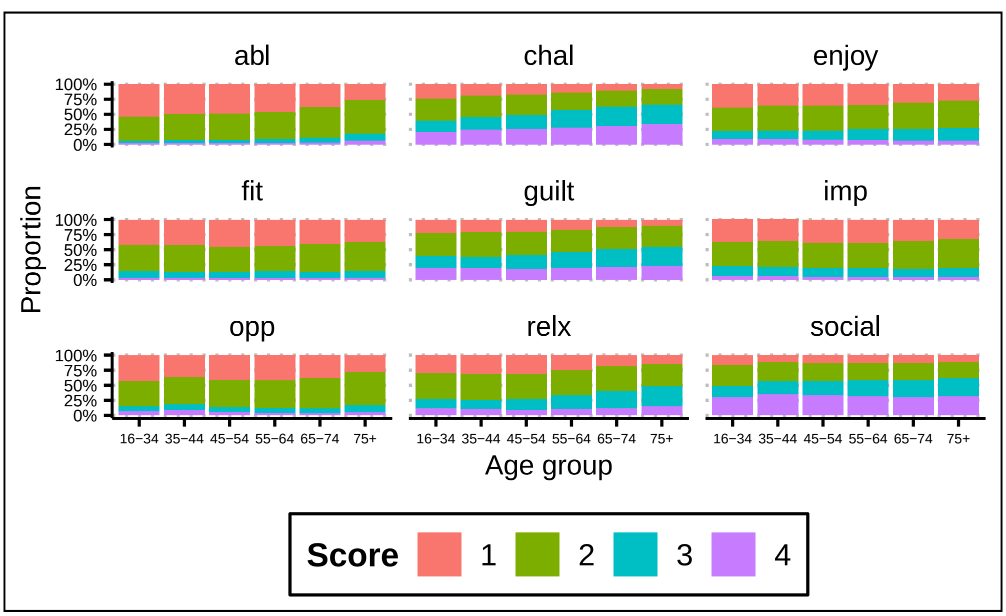

Figure 2: Distribution of adult responses for each motive on the Likert scale.

Each item is 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. As seen in Figure 2, the proportion of adults expressing strong positive agreement declines with age for most motive items. Older adults were less likely than younger adults to strongly endorse beliefs such as feeling capable of engaging in PA, valuing it for the challenge, or pursuing it for enjoyment and fitness. They were also less likely to report strong guilt for not exercising, to perceive sufficient opportunities for activity, or to consider PA 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 due to significant deviations in survey design for other years from the adult version.

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. Pupils either completed the survey at school under teacher supervision or as homework. To encourage participation, schools received credits for sports equipment and school-level feedback reports.

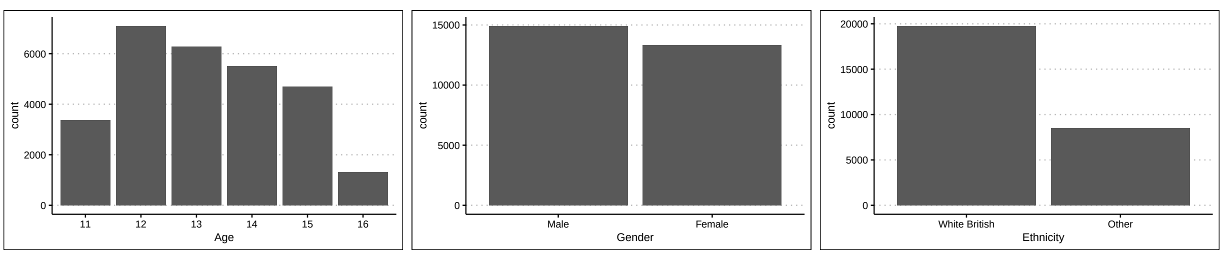

Figure 3: Distribution of age, gender, and ethnicity in youths.

47% of the sample are female, and 70% are White British (Figure 3). Although 16-year-olds represent a small proportion of the sample (4.63%), they were not collapsed with the 15-year-olds. The transition from age 15 to 16 marks a distinct developmental and social stage, such as reaching legal thresholds, completing compulsory schooling, and gaining increased autonomy. Retaining this distinction allows examination of possible developmental turning points.

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 (Figure 4), except for social, guilt, and relaxation. Response patterns 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 PA.

Statistical Analysis

Multigroup SEM was used to to compare mean levels of exercise motives between adults and youths, followed by LCA to identify distinct motivational profiles within each group. Class membership was then regressed on

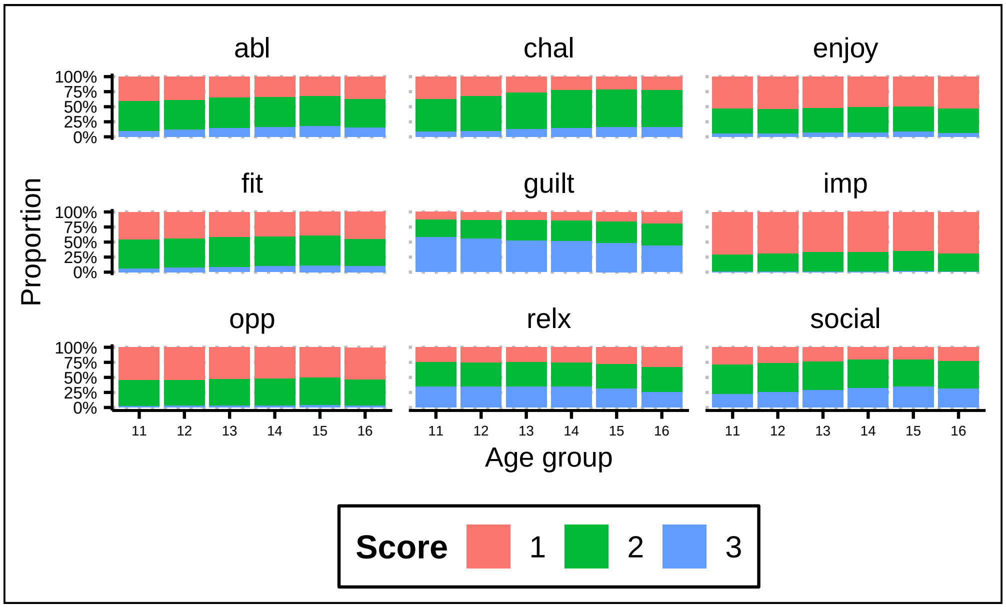

Figure 4: Distribution of youth responses for each motive on the Likert scale.

age group using multinomial logistic regression, allowing for a direct comparison of the effect of age on profile membership between adults and youths. Two motive items (challenge and importance) were excluded from multigroup 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

Differences in the slopes of motive items were examined while controlling for demographic factors (see Appendix E for model specification). This approach directly addresses H1(a), H1(b), and H1(c) by testing whether the strength of association between each motive item and weekly PA varies between youths and adults.

Table 1: Proportion of "strongly agree" responses for adults (left) and youths (right).

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

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

To account for differences in Likert scales between adults and youths, all motive items were dichotomized into “strongly agree” and “not strongly agree”. As shown in Table 1, the distributions of positive responses exhibit a left skew in both adults and youths, suggesting that participants were less likely to choose the highest agreement category across items. 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. Ethnicity, gender, and age were controlled for in all models.

Prior to fitting the multigroup 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. Given the conceptual similarity of these motive items, a level of correlation is expected and largely unavoidable. Standardized residual correlations were also examined to evaluate local fit for both youth and adult models. Most residuals were below 0.35, indicating generally acceptable correspondence between observed and model-implied correlations. The largest residuals occurred among closely related motive items (enjoyment, fitness, opportunity, and relaxation), exceeding 0.4. This misfit likely reflects conceptual overlap and the use of dichotomized indicators. Nevertheless, residuals involving demographics and PA minutes were consistently low. These localized discrepancies do not affect the primary purpose, which is to test whether the strengths of associations, rather than the predictive power of motives on PA, differ across groups.

Latent Profile Analysis

LCA was conducted separately for youths and adults to identify distinct motivational profiles, using the Likert-scale motive items as indicators. Ethnicity and gender were included as covariates predicting class membership. Multiple sets of random starting values were used to ensure solution stability and convergence. The final sample included 116,018 adult and 28,269 youth respondents.

The optimal number of classes was determined based on AIC, BIC, relative entropy, the Lo-Mendell-Rubin likelihood ratio test (LMR), the bootstrap likelihood ratio test (BLRT), class proportions, and substantive interpretability. Multinomial logistic regression with age as a predictor was then applied to examine whether age influences profile membership, with odds ratios and 95% confidence intervals calculated by exponentiating the estimated coefficients. This approach directly tests whether the probability of belonging to lower-motivation profiles increases with age, addressing H2(a) for adults and H2(b) for youths."

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 motive 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; Rosseel *et al.*, 2025). LCA and related statistics were conducted using packages poLCA (Linzer & Lewis, 2011) and poLCAExtra (Caron, 2024).

Results & Discussion

Multigroup SEM

Significant differences between adults and youths were observed in the strength of associations between motive items and weekly PA. Coefficients (Table 2) represent the estimated change in weekly PA minutes associated with strong agreement for each binary motive.

Table 2: 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

As shown in Table 2, enjoyment and guilt both have a stronger effect in youths than in adults, although the magnitude of these effects remains modest at 24 and 17 minutes, respectively. While this supports H1(a), social motive has a larger effect in adults instead at a difference of 24 minutes. The observed discrepancy 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 *et al.* (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 *et al.* (2018) categorizes social motive as "social influence", encompassing the impact of friends, parents, family members, coaches, and health professionals on an individual's PA 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 PA in survey instruments can obscure the specific motives associated with different activities. For example, Vuckovic & Duric (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 PA 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.

Fitness was a stronger predictor among adult, with a difference of 25 minutes. Though it was assumed that adults would place greater value on stress-relief methods, relaxation was more influential in youths. Similar to H1(a), not all elements of H1(b) are supported. Nevertheless, several developmental and contextual factors may provide insight. Not only was achieving relaxation was one of the most commonly reported motives for participation of PA in adolescents aged 16 and older (Ashford *et al.*, 1993), it's also a key determinant of fun in youth sports that promotes sustained engagement (Visek, 2015). In addition, Teuber (2024) reported that engagement in PA not only reduced stress but also enhanced perceived academic performance in university students. While this sample is older than the youths in the present study, the academic pressure context is analogous. On the other hand, elevated momentary stress was found to predicts lower subsequent PA (Do *et al.*, 2021). Since the present study does not assess causality, there is the possibility that relaxation drive higher PA rather than the reverse. More broadly, personal experiences appear to foster understanding of the benefits of PA, which may in turn drive PA engagement (Kostamo, 2019). Although 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), environmental opportunity had a stronger effect among adults, with the biggest difference among all motives at 63 minutes. This discrepancy may be due to youths having more consistent access to facilities such as school gyms and playgrounds, while adults are limited by the rising opportunity costs associated with PA participation. This is particularly true among highly educated adults who are aware of the health benefits, but often hold sedentary (Brown & Roberts, 2011). Furthermore, women often face fewer chances to engage in PA than men, particularly in cultural contexts where they are primarily responsible for household caretaking, which restricts access to outdoor or leisure-based activity (Jalaluddin, 2024).

These findings demonstrate clear shifts in motivational drivers. Youths appear 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 adult engagement in PA 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, identified, and introjected regulation tend to weaken. 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. In the context of the TPB, the results imply personal valuation and perceived social expectations 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

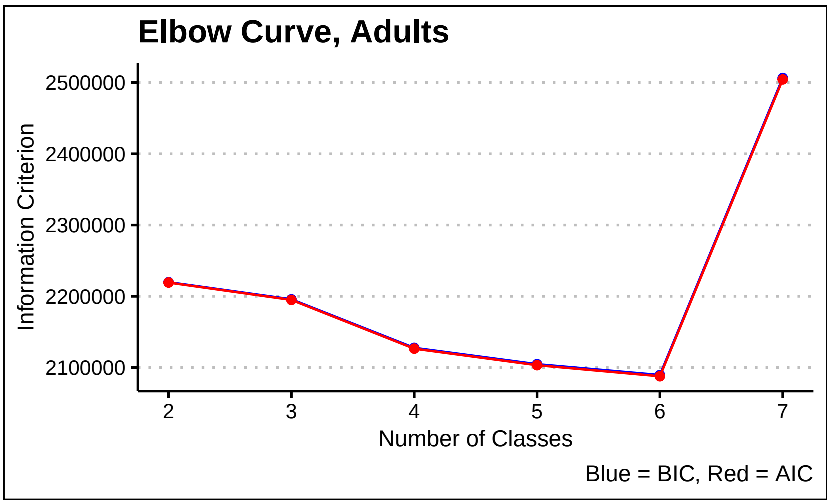

Figure 5: Elbow curve of AIC and BIC values across different numbers of latent classes in adults.

Latent class models ranging from 3 to 6 classes all demonstrated low AIC and BIC values (Figure 5), significant LMR and BLRT results, and reasonable average posterior entropy per class. Starting form the 4-class model, there appears to be diminishing returns in lowering AIC and BIC values (Figure 5), suggesting that adding more than 4 classes did not provide a substantial improvement in model fit. While both the 3-class and 4-class models have adequate relative entropy values at 0.8916 and 0.7945, respectively, the 4-class solution contains two groups with nearly identical response patterns, which undermines substantive interpretation. The bootstrap likelihood ratio test was used to assess the significance of performance differences. All models except the 7-class were found to be significant, with a preference for the 6-class solution. Nevertheless, the 3-class model is selected for its balance between simplicity and the ability to distinguish meaningful motivational profiles. Fit indices for all models can be found in Appendix D.

Figure 6 shows the distribution of responses across each latent class.

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

Class 2 is characterized by very low probabilities of strongly agreeing with opportunity 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 PA. This group is labelled the Low Motivation class. It represents a

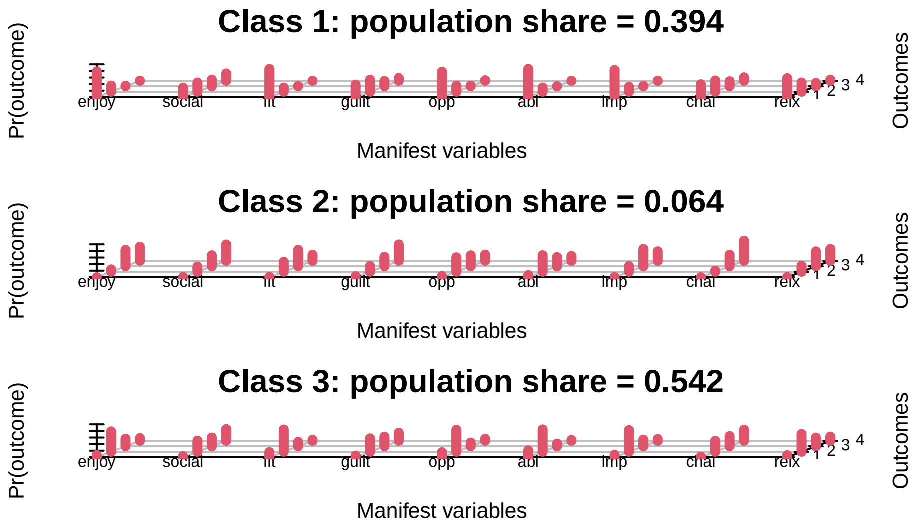

Figure 6: Frequency of adult responses for each motive by class membership.

relatively small proportion of the sample (~6%), which corresponds to the patterns observed in the raw data, where very few respondents selected negative responses in general.

Class 3 exhibits a mixed attitude toward various motives, with an almost even mix of positive and negative endorsement across the board. It represents adults who show more ambivalent responses overall. This group is labeled the Mixed Motivation class.

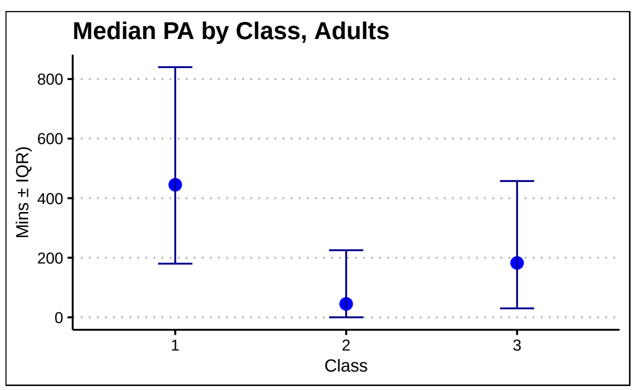

Figure 7: Weighted median and interquartile range of minutes exercised per week for adults by class.

There exists substantial differences in the median of weekly PA minutes, as seen in Figure 7. The High Motivation class exhibits the highest levels (445), followed by the Mixed Motivation class (182.5), and finally the Low Motivation class (45). Notably, the interquartile range is positively associated with activity level, highlighting considerable variability, particularly among the most highly active class.

The distribution of age groups highlights notable patterns in motivational profiles (Figure 8). The High Motivation class is consistently the second most populous across age groups, gradually declining with increasing age. The Low Motivation class remains the smallest in all age groups, with its relative size 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 to mixed motivation over time.

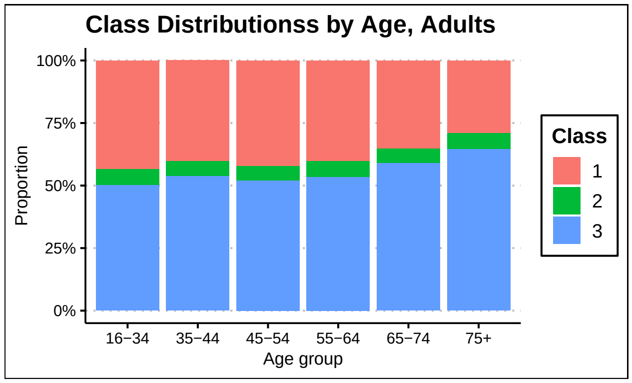

Figure 8: Proportion of adults in each class across age groups.

Table 3: Odds ratios for adult class membership across age groups, with the youngest group (16–34 years) as the reference.

	16-34 (ref)	35–44	45–54	55–64	65–74	75+
Low Motivaation	0.149	1.023	0.9118	1.046	1.143	1.515
Mixed Motivation	1.153	1.159	1.0696	1.149	1.453	1.930

Multinomial logistic regression was applied to directly examine the relatioship between age groups and class membership, with the High Motivation class and youngest group (16–34) as reference (Table 3). The youngest adults are more than 6.6 times as likely to belong to the High Motivation class compared to the Low Motivation class. Although their odds of falling into the Mixed Motivation group are 15% higher, this may be due to the larger size of that group. For the Low Motivation category, no statistically significant differences are found between the 35–44 and 55–64 age groups and the reference category. Other age groups show similar odds, except for those aged 75 and above, who are 1.5 times more likely to be in the Low Motivation class. Meanwhile, the likelihood of being in the Mixed Motivation group rises with age, with adults aged 65–74 being 1.45 times and those aged 75+ being 1.93 times more likely than the youngest adults. While class membership remains relatively stable among adults under 65, those older than 65 are more likely to be classified within lower or mixed motivation groups, consistent with H2(a).

The marked reduction in motivation and PA observed among older adults may stem from the interaction of perceived physical limitations and changing psychosocial influences. Advancing age is frequently accompanied by internalised beliefs about inevitable physical decline, which can erode perceptions of competence and autonomy, reducing intrinsic motivation (Palombi *et al.*, 2025). At the same time, negative physiological experiences such as pain or fatigue, alongside diminished perceived control over exercise, reduce both favourable attitudes and intentions to participate, while social norms and group identification exert limited influence (Meredith *et al.*, 2023; Tsai, 2022). The combination of unmet psychological needs and weakened intention-forming processes helps explain the steep drop in both motivation and participation.

Youths

Increasing the number of classes beyond 4 led to a decrease, as evidenced by a sharp increase in AIC and BIC (Figure 9). The penalty for model complexity likely outweighed any improvements in fit. Consequently, the 3-class and 4-class solutions were the only viable candidates. The LMR and BLRT results further supports this, indicating significance only for these two models, with a preference for the 4-class solution. Both models show acceptable relative entropy values at 0.7998 and 0.7473, but the higher relative entropy for the 3-class model suggests it offers a more nuanced classification of individuals. Similar to the adults, the 4-class model also resulted in two very similar classes, suggesting that the additional class did not add meaningful

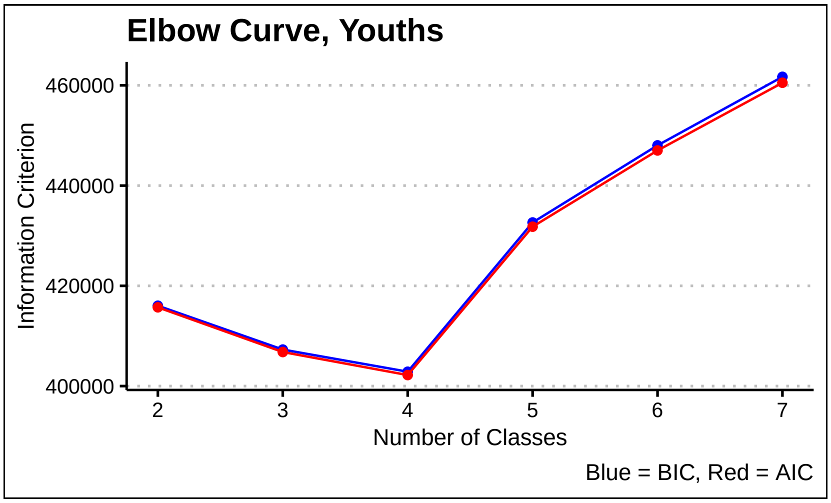

Figure 9: Elbow curve of AIC and BIC values across different numbers of latent classes in youths.

differentiation. Given these considerations, the 3-class model was selected.

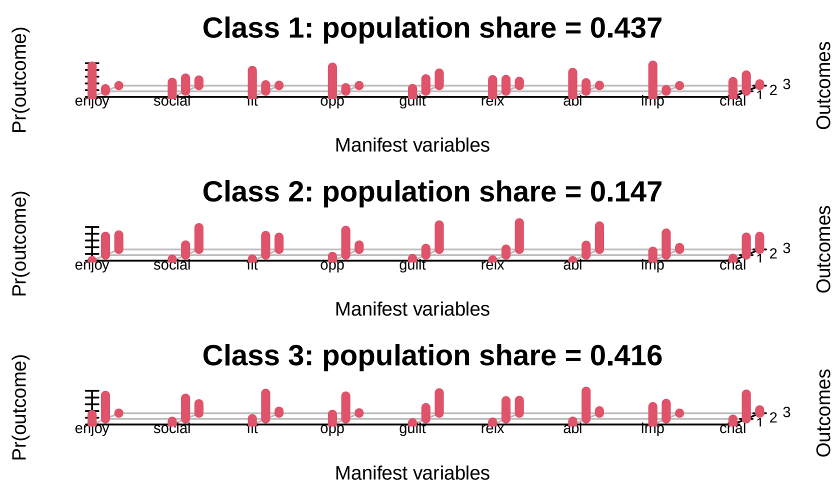

Figure 10: Frequency of adult responses for each motive by class membership.

Figure 10 illustrates the response patterns for each latent class among youths.

Class 1 represents youths who consistently report positive attitudes toward a wide range of motives. 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 class is labeled the High Motivation class.

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 PA. This class is labeled the Low Motivation class, and represents a relatively small proportion of the sample. This is consistent with the raw data, where few respondents selected negative responses.

Class 3 exhibits a moderate attitude toward most motives, with moderate positive endorsements of enjoyment, fitness, opportunity, ability, and importance. Disagreement and strong agreement are both uncommon.

This group falls in the middle, representing generally positive but not strongly emphatic motivation toward PA. This class is labeled the Moderate Engagement class.

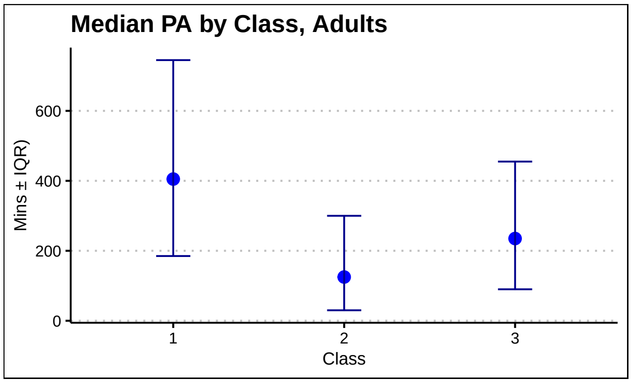

Figure 11: Weighted median and interquartile range of minutes exercised per week for youths by class.

Similar to adults, significant differences in the median weekly PA minutes are observed across the classes, along with substantial variability within each class (Figure 11). The High Motivation class boasts the highest number (405) and highest interquartile range, followed by the Moderate Motivation class (235), and then the Low Motivation class(125).

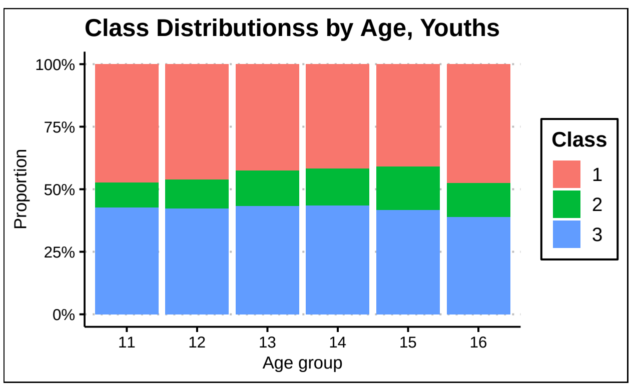

Figure 12: Proportion of youths in each class by age.

Figure 12 highlights notable differences in the distribution of age. The High and Moderate Motivation classes are roughly similar in size, with the latter decreasing with age, except for the sudden increase at age 16. The Low Motivation class is smaller than the other two but still larger than in the adult sample. It steadily gains size with age, with a slight dip at age 16. These patterns suggest that while motivation generally declines during adolescence, a significant portion of youths maintain moderate to strong motivation throughout. Additionally, some youths may experience a boost in motivation during late adolescence.

Table 4: Odds ratios for youth class membership across ages, with 11-year-olds as the reference.

	11 (ref)	12	13	14	15	16
Low Motivation	0.2086	1.197	1.586	1.701	2.036	1.3617
Moderate Motivation	0.8991	1.021	1.129	1.158	1.134	0.9087

The multinomial logistic regression revealed statistically significant differences across all age groups and classes, with the reference group being 11-year-olds in the High Motivation class (Table 4). At age 11, youths are approximately 5 times less likely to belong to the Low Motivation class compared to the reference group, while their odds of belonging to the Moderate Motivation class are about the same. For the Low Motivation class, the odds of membership increase steadily with age, peaking at age 15, before slightly decreasing at age 16, from twice as likely to 1.36 times as likely. This supports the pattern observed in Figure 12, suggesting that these individuals may have shifted to the High Motivation class. In contrast, the odds for the Moderate Motivation class remain relatively stable across ages, with a slight decrease at age 11 and 16. These findings highlight a shift toward lower motivation as youths age, with the slight exception of 16-year-olds, generally supporting H2(b).

There is a steady and substantial increase (20–30% per year) in the likelihood of belonging to the low motivation class, a finding consistent with prior research (Shao & Zhou, 2023; Mendonça *et al.*, 2014). This trend aligns with prior observations that younger youths are more motivated by mastery goals, which emphasise learning and competence and are positively associated with PA levels, compared to older adolescents (Sahin *et al.*, 2016). Conversely, performance-avoidance goals, which increase with age, are negatively associated with enjoyment (Barkoukis *et al.*, 2024) and contribute to declines in intrinsic motivation (Guan *et al.*, 2023). This pattern suggests that developmental shifts in goal orientation may partly explain the observed increase in low-motivation profiles. Additionally, parental modelling and logistical support play a crucial role in fostering PA habits, but their influence declines with age (Davison & Jago, 2009). Around age 16, as youths gain greater autonomy and become less dependent on adult support, intrinsic motivation may increase, contributing to the observed rise in motivation and PA engagement. Concurrent legal and social transitions, such as eligibility for independent travel or part-time work, further expand opportunities for participation.

Cross-Group Comparison

Examining age effects across youths and adults reveals a generally consistent pattern. In both groups, the youngest individuals are highly unlikely to belong to lower motivation profiles. Among adults, membership remains relatively stable throughout middle adulthood, with a marked decline in motivation emerging only in older age, potentially reflecting the stability of life circumstances until retirement. In youths, membership in both Low and Moderate Motivation classes increases steadily with age, with the increase in Low Motivation considerably more pronounced.

These patterns suggest that while age consistently predicts an increased likelihood of lower motivation, the timing and trajectory differ across developmental stages. In adolescence, gradual increases may reflect accumulating social and personal pressures that reduce engagement, whereas in older adulthood, the abrupt rise may be linked to life transitions such as retirement, health decline, or reduced structured activity opportunities. Despite these differences, the general trend supports the hypothesis that age exerts a comparable effect on motivational profile membership in youths and adults, highlighting the relevance of age-related processes in shaping motivational engagement across the lifespan.

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 nuanced support for the proposed hypotheses. Exercise motives were shown to differ in their influence on PA across developmental stages, but not uniformly as predicted. Social motives were unexpectedly stronger among adults than youths, and relaxation motives were stronger in youths, indicating that H1(a) and H1(b) are only partially supported. Contrary to H1(c), perceived opportunity had a substantially greater influence on PA in adults than in youths, suggesting that environmental and structural factors may constrain adult activity more than previously assumed. These deviations highlight that motives are context-dependent and shaped by life-stage constraints, implying that simple age-based assumptions about motive strength may overlook critical social and environmental influences.

H2(a) and H2(b) received more consistent support. Distinct motivational profiles were identified within both youths and adults, and age was associated with systematic shifts in profile membership. Among adults, motivation gradually declined with age, with the oldest adults exhibiting the steepest drop toward Low Motivation profiles, consistent with H2(a). Among youths, High Motivation class membership also declined gradually, but the oldest adolescents showed a sudden increase, providing only partial support for H2(b). These patterns suggest that developmental trajectories of PA motivation are shaped by gradual changes in life-stage priorities that may accelerate declines in intrinsic engagement.

Overall, the results demonstrate that age influences both the strength of individual exercise motives and the configuration of motivational profiles, but the relationships are complex and partially counter to theoretical predictions.

Policy Implications

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.

For youths, providing choice in activity type, intensity, and scheduling can help sustain engagement, particularly as enjoyment and personally meaningful goals are primary motivators. Fun, low-pressure activities remain essential, given that relaxation and stress relief are consistently valued motives. Adult support should focus on logistical assistance and modelling rather than mastery or performance pressure, as avoidance tendencies naturally increase with age. Around age 16, when adolescents gain greater control over their schedules and become less reliant on adult support, policies should facilitate access to resources, guidance, and safe environments for self-directed activity, helping translate increased autonomy into sustained intrinsic participation.

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, particularly 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 influenced reported PA or demographic details.

A major limitation is that the data were not collected using an established, validated questionnaire (e.g., BREQ-2), so the corresponding theoretical constructs were not formally operationalised. Each variable relied on a single-item response, potentially limiting validity and reliability. To ensure comparability across groups, only motive items with identical or near-identical wording were retained, potentially omitting relevant constructs. PA measures were highly skewed. 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, and relationship status were not considered, and the cross-sectional design prevents causal inference about developmental changes in motivation or behaviour.

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Appendix A - Survey Questions

Adults

Table 5: 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 6: 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. Both are capped at 1680 minutes per week.

Vigorous Exercises

- 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

- 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 exercises were combined into a single variable (original variable name: mins_modplus_outschool_Week_ALL). According to Sport England (2024), moderate activity involves raising one's heart rate and feeling slightly out of breath, whereas vigorous activity refers to exertion that causes breathlessness or sweating, such that only a few words can be spoken without pausing for breath.

Moderate and Vigorous Exercises:

- 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 - Likert-Scale Response Summary Statistics

Table 7: 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 8: 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 - LCA Models and Fit Indices

Adults

Table 9: LCA fit indices, adults.

nclass	llike	AIC	BIC	Rel.Entropy	LMR	p
2	-1109600	2219314	2219864	0.8908	295306	0
3	-1097393	2194960	2195800	0.8916	23736	0
4	-1063172	2126578	2127708	0.7945	66540	0
5	-1051546	2103386	2104807	0.7968	22605	0
6	-1043751	2087857	2089567	0.7980	15156	0
7	-1251957	2504327	2506327	0.9931	-404839	1

Table 10: BLRT results, adults.

test	H0__llik	X2loglik__diff	npar	mean	s.e.	p
2 vs 1	-1261474	303747	28	37.83	10.158	0
3 vs 2	-1109600	24414	28	43.09	8.093	0
4 vs 3	-1097393	68442	28	3860.44	8531.979	0
5 vs 4	-1063172	23251	28	46.22	5.767	0
6 vs 5	-1051546	15590	28	51.65	5.543	0
7 vs 6	-1043751	-416411	28	37.03	16.117	1

Youths

Table 11: LCA fit indices, youths.

nclass	llike	AIC	BIC	Rel.Entropy	LMR	p
2	-207816	415711	416032	0.8436	53567	0
3	-203336	406791	407286	0.7998	8679	0
4	-201018	402198	402866	0.7473	4489	0
5	-215798	431800	432642	0.8382	-28629	1
6	-223382	447010	448025	0.9577	-14690	1
7	-230114	460516	461704	0.9897	-13040	1

Table 12: BLRT results, youths.

test	H0__llik	X2loglik__diff	npar	mean	s.e.	p
2 vs 1	-235471	55309	19	25.40	11.693	0
3 vs 2	-207816	8961	19	26.85	7.667	0
4 vs 3	-203336	4635	19	26.49	4.933	0
5 vs 4	-201018	-29560	19	26.57	11.658	1

Appendix E - R Code (Data Cleaning)

NOTE: The initial section of the code, which handles basic reading and processing of the raw data files, has been commented out since the data were saved as RDS objects to reduce computation time during report knitting.

```
> ################### 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 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 F - R Code (SEM)

```
> ################### SEM Process ###################
>
> # 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
+ '

> 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 G - 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=5)
> # 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)

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

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

> # 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))

> colnames(or.ch) <- c("11 (ref)", "12", "13", "14", "15", "16")

> rownames(or.ch) <- c("Low Motivation","Moderate Motivation")

> 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 = 5)
> # 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)

> # 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))

> colnames(or.ad) <- c("16-34 (ref)", "35-44", "45-54", "55-64", "65-74", "75+")

> rownames(or.ad) <- c("Low Motivaation","Mixed Motivation")

> 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")

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

Appendix H - R Code (Visualization)

```
> ################### All visualizations used in final report ###################
> 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)

> # 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()

> # 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()

> # 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 Curve, Youths",
+        caption = "Blue = BIC, Red = AIC") +
+   theme_clean()

> 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()

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

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

> 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 = "Mins ± IQR)",
+        title = "Median PA by Class, Adults") +
+   theme_clean()

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

> 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", title = "Class Distributionss by Age, Youths
+   scale_y_continuous(labels = scales::percent_format()) +
+   theme_clean()

> 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),
+         , axis.text.x = element_text(size = 5))

> # 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 Curve, Adults",
+        caption = "Blue = BIC, Red = AIC") +
+   theme_clean()

> 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()

> # 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.class4.ad <- data.frame(
+   Class = 1:ncol(post4.ad),
+   Proportion = as.numeric(class.size4.ad),
```

```
+   Avg_Posterior = round(ave.pp4.ad, 4)
+ )

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

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

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

> 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 = "Mins ± IQR)",
+        title = "Median PA by Class, Adults") +
+   theme_clean()

> 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", title = "Class Distributionss by Age, Adults
+   scale_y_continuous(labels = scales::percent_format()) +
+   theme_clean()

> 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 = 5))

> # 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 I - 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

gg.vars.ad


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


gg.vars.ch

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


plot(LCAE.ad, nclass = 2, main = "Response Distributions by Class, Adults")


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'))

gg.elbow.ch

plot(LCAE.ch, nclass = 2, main = "Response Distributions by Class, Youths")
```

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

```r
       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)
```