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Patterns of maladaptive exercise behavior from ages 14–24 in a longitudinal cohort

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Background: Exercise for weight loss and maladaptive exercise (exercise that results in negative consequences or interference with daily life) are common behaviors among youth and are associated with increased risk of disordered eating symptoms. The current study clarifies processes that influence exercise-related risk in adolescence and young adulthood, including the frequency with which young people transition between engaging in exercise for weight loss and experiencing negative consequences of this behavior. **Method:** Participants from the Avon Longitudinal Study of Parents and Children (ALSPAC) reported on eating disorder cognitions at age 14, and exercise behavior at ages 14, 16, 18, and 24 years old. Analyses examined rates of transition between the categories of 'No Exercise for Weight Loss', 'Exercise for Weight Loss', and 'Maladaptive Exercise' over time, identified overall trends in endorsement of exercise for weight loss and maladaptive exercise, and clarified predictors of these behaviors. **Results:** Endorsement of exercise for weight loss and maladaptive exercise increased over time in both males and females. Those in the 'Exercise for Weight Loss' category were more likely than those in the 'No Exercise for Weight Loss Category' to transition to 'Maladaptive Exercise' over time. Body mass index (Age 13) and fear of weight gain (Age 14) were consistent predictors of maladaptive exercise across sex. **Conclusions:** Results support re-framing motivations for exercise in youth away from weight loss at a population level and targeting reductions in fear of weight gain for high-risk individuals. **Keywords:** Maladaptive exercise; exercise for weight loss; eating disorder; ALSPAC; adolescence.

Introduction

Exercise, which is often associated with mental and physical health benefits (Chekroud et al., 2018; Deslandes et al., 2009; Penedo & Dahn, 2005), can also become maladaptive, particularly in the context of disordered eating (Dalle Grave, Calugi, & Marchesini, 2008; Dittmer, Jacobi, & Voderholzer, 2018). Though definitions vary, a broad conceptualization of maladaptive exercise includes exercise that exhibits one or more of the following qualities: (a) exercise that is driven or compulsive in nature, (b) feelings of distress or guilt arise when an individual is unable to exercise, (c) exercise that interferes with ability to engage in school, work, or daily activities, (d) the inability to refrain from exercise despite circumstances (e.g., illness, injury) in which it is not recommended (Dittmer et al., 2018; Gorrell, Flatt, Bulik, & Le Grange, 2021; Scharmer, Gorrell, Schaumberg, & Anderson, 2020). Engagement in high levels of exercise may also spur onset and exacerbation of other disordered eating behaviors, as the activity-based anorexia rodent model suggests that activity in the context of dietary restriction can preempt entrenched hyperactivity and restriction (Adan, Hillebrand, & Danner, 2010), and retrospective reports of individuals with eating disorders (EDs) suggest that maladaptive exercise can be an early-developing ED feature (C. Davis, Kennedy, Ravelski, & Dionne, 1994; Stiles-Shields, Goldschmidt, Boepple, Glunz, & Le Grange, 2011). Once entrenched, maladaptive exercise patterns can be a pernicious and debilitating ED symptom and a potential marker of poor prognosis (Brosof, Williams, & Levinson, 2020; Dalle Grave et al., 2008; Monell, Levallius, Forsén Mantilla, & Birgegård, 2018; Solenberger, 2001).

Maladaptive exercise most often arises, and may coincide with eating pathology, when individuals also report weight loss as a primary motivation for exercising (Scharmer et al., 2020; Zmijewski & Howard, 2003). While limited research has investigated maladaptive exercise in young adolescents, the exercise for weight control subscale of the exercise dependence questionnaire demonstrates robust associations with disordered eating among college students, with strong associations between exercise dependence symptoms and disordered-eating attitudes (Zmijewski & Howard, 2003). Further, Scharmer et al. (2020) found that compulsive exercise to control weight and manage negative affect were strongly associated with severity of eating pathology in a sample of college students with elevated eating pathology. Among individuals with eating disorders, maladaptive exercise with a weight-control motive is

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common, with a systematic review finding that an average of 61.5% of adolescents diagnosed with an eating disorder also demonstrate features of compulsive exercise (Fietz, Touyz, & Hay, 2014). In our previous research, we found that exercise for weight loss was a commonly reported behavior among adolescents, and that this behavior was associated with prospective eating disorder risk (Schaumberg, Robinson, Hochman, & Micali, 2022). Overall, while exercising with a weight-control motive is not in and of itself considered a maladaptive behavior, it may portend risk for the development of negative consequences of exercise and additional eating disorder behaviors.

While the potential maladaptive features of exercise among youth are concerning, exercise behavior is more generally associated with positive effects on child and adolescent health including: improved cognitive functioning, less risk for depression (Biddle, Ciaccioni, Thomas, & Vergeer, 2019), and, among youth with obesity, favorable impacts on cardiorespiratory fitness (García-Hermoso, Ramírez-Vélez, & Saavedra, 2019). Thus, a relevant question when designing exercise recommendations and interventions is what risk factors give rise to maladaptive exercise specifically, and how might interventions promote exercise while ensuring that this behavior is adaptive and sustainable. Clarification regarding the prevalence and early predictors of high-risk exercise behavior during adolescence could build knowledge necessary to prevent maladaptive exercise patterns from taking hold. Previous research highlights several potential predictors of maladaptive exercise in young people, including, at a social level: pressures to conform to body image ideals and social comparisons (Reynolds, Plateau, & Haycraft, 2022), at a psychological level: weight and shape concerns, negative affect, thinness expectations (Gorrell et al., 2021), and weight-loss motivations for exercise (Scharmer et al., 2020), and, at a biological level: genetic risk for obsessive-compulsive disorder and/or anorexia nervosa (Yilmaz et al., 2022). A recent review noted that predictors of maladaptive exercise are an under-researched area and include limited prospective work that would aid in defining potential treatment targets (Reynolds et al., 2022). Further examination of traits in early adolescence that predict engagement in maladaptive exercise could provide additional insights as to which adolescents may be at risk for the development of this behavior as they traverse a sensitive developmental period for eating disorder risk.

Altogether, evidence suggests that engaging in exercise that is motivated by weight loss could, in some cases, escalate to maladaptive exercise which may potentiate ED risk, though additional investigation is necessary to clarify processes that influence exercise-related risk and the frequency with which young people transition to and from maladaptive patterns of exercise. Further, identification of early predictors of maladaptive exercise could aid in identifying youth at risk for the development of disordered eating.

Current study

The current study extends a longitudinal investigation of exercise for weight loss and maladaptive exercise in the ALSPAC cohort across a developmental window from adolescence to young adulthood (aged 14–24). Specifically, we examined the frequency of transition among exercise states, based on the three categories of 'No Exercise for Weight Loss', 'Exercise for Weight Loss', and 'Maladaptive Exercise', among males and females (using sex assigned at birth) at ages 14, 16, 18, and 24 years old. We identified rates of transitions between these exercise states over time along with preliminary predictors of these transitions. Further, we characterized overall risk for engaging in maladaptive exercise across age and identify potential demographic or early (age 14) ED cognition variables that may enhance risk for maladaptive exercise throughout adolescence. Based on previous literature (Allen, Crosby, Oddy, & Byrne, 2013; Davis, Guller, & Smith, 2016; Schaumberg et al., 2022), we hypothesized that exercise for weight loss and maladaptive exercise would be relatively common and moderately persistent, with those who engage in this behavior likely to continue engagement across adolescence. Further, we hypothesized that ED cognitions assessed at age 14 will be associated with higher likelihood of exercise for weight loss and maladaptive exercise across adolescence. Specific aims are as follows:

Study aims

Aim 1. To investigate rates of transition between 'No Exercise for Weight Loss', 'Exercise for Weight Loss', and 'Maladaptive Exercise' groups from ages 14–24, and characterize predictors of transitions to 'Maladaptive Exercise' among males and females.

H1a. Maladaptive exercise will be moderately persistent; that is, individuals will be likely to remain in this category once they transition into the category.

H1b. Transitions between the 'Exercise for Weight Loss' and 'Maladaptive Exercise' categories will be more common than transitions between the 'No Exercise for Weight Loss' and 'Maladaptive Exercise' categories.

Aim 2. To examine overall changes in the probability of exercise for weight loss and maladaptive exercise from ages 14–24 and clarify baseline predictors of shifts in these probabilities across adolescence.

H2a. The prevalence of exercise for weight loss and maladaptive exercise will show modest increases with age, reflecting transition through peak age of onset for EDs during late adolescence.

H2b. ED cognitions at age 14 will predict maladaptive exercise and exercise for weight loss across adolescent and young adult development, with strongest prediction at most proximal timepoints.

Method

Replication

All analytic code used in the development of this manuscript is available at https://github.com/kschaumb/alspac-dex-1-bookdown for replication.

Sample – the ALSPAC cohort

The ALSPAC Cohort (Boyd et al., 2013; Fraser et al., 2013; Northstone et al., 2019) was established to understand how genetic and environmental characteristics influence health and development in parents and children. Pregnant women living in the geographical area of Avon, United Kingdom, who were expected to deliver between April 1, 1991 and December 31, 1992, were invited to participate in the study. 14,541 pregnancies were enrolled; 13,988 children from these pregnancies were alive at 1 year. An additional 913 children were enrolled during subsequent phases of enrollment, with a total sample size alive at 1 year of 14,901. All women gave informed and written consent. Among twin pairs, one twin per pair was randomly excluded from the current study. A fully searchable ALSPAC data dictionary is available at https://www.bristol.ac.uk/alspac/researchers/our-data. Study data at age 24 were collected and managed using REDCap electronic data capture tools hosted at the University of Bristol (Harris et al., 2009). REDCap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies. The sample utilized for the current study includes individuals reporting exercise for weight loss data from ages 14–24 years. Sample size ranged from 3,229 (age 18) to 5,950 (age 14), with slightly more female than male participants responding at all time points (see Figure S1). Across all time points, 3,319 male and 4,360 female participants completed at least one assessment of exercise for weight loss. Participants reporting exercise for weight loss data at one or more time points were included in analyses. At 32 weeks of gestation, mothers reported their own and their partner's racial/ethnic background. From these reports, child's ethnicity was derived as 'White' or 'non-White'. Of children included in the present analysis, the majority (84.93%) were identified as White, with a minority (3.86%) identified as non-White, and 11.21% missing race/ethnicity data at this assessment. Among mothers of children included in the present analysis, 87.99% identified as White, 10.05% were missing race/ethnicity data, and 0.57% reported their ethnic background as Other. Additional maternal racial/ethnic backgrounds that were present in <0.5% of the total sample (from most to least frequent) were: Indian, Black Caribbean, Other Black, Chinese, Pakistani, Black African, and Bangladeshi.

Ethical consideration. Ethical approval for this study was granted by the ALSPAC Law and Ethics Committee and Local Ethics Committees. Informed consent for the use of data collected via questionnaires and clinics was obtained from participants following the recommendations of the ALSPAC Ethics and Law Committee at the time.

Measures

Socioeconomic status (SES). Parental occupation was assessed for both mother and partner during child gestation. Occupations were then classified as unskilled (0), partly skilled (1), skilled manual (2), skilled non-manual (3), managerial and technical (4), or professional (5). Of reported parent occupations, the highest reported occupation was used as a proxy for parent SES, to be treated as a continuous covariate.

ED cognitions. ED cognitions were assessed when children were 14 years of age. Relevant variables for the current analyses included: body dissatisfaction, thin-ideal internalization, and fear of weight gain.

Body dissatisfaction: Body dissatisfaction was assessed via an 11-item scale adapted from the satisfaction and dissatisfaction with body parts scale (Stice, 2001), which has been used in several previous studies involving the ALSPAC Cohort (Bornioli, Lewis-Smith, Slater, & Bray, 2021; Bornioli, Lewis-Smith, Smith, Slater, & Bray, 2019; Schaumberg et al., 2018). Among the 11 items, one item differs between the sexes (satisfaction with 'breasts' is specified for females and 'build' for males). Responses are graded on a 5-point Likert scale from *Extremely Satisfied* (1) to *Extremely Dissatisfied* (5). Reliability was high in both females (Cronbach's $\alpha = .91$) and males (Cronbach's $\alpha = .95$). Body dissatisfaction was scored using the mean of all items, with higher scores indicating greater body dissatisfaction, which was standardized within gender.

Thin-ideal internalization: Thin-ideal internalization was assessed using the Ideal-Body Stereotype Scale-Revised (IBSS-R; Stice, Shaw, & Nemeroff, 1998). Females and males were both asked six questions, three of which were the same and three of which were gender-specific, assessing the perceived attractiveness of same-sex individuals based on physical characteristics (e.g., being 'lean', 'tall', 'petite'). Items are rated on a 5-point Likert scale ranging from *Strongly Disagree* (0) to *Strongly Agree* (4). (Cronbach's $\alpha = .55$ for females; .71 for males; Calzo, Austin, & Micali, 2018). Standardized mean within gender was utilized in the analysis.

Fear of weight gain: Fear of weight gain was assessed via a single item asking the degree to which participants have worried about gaining a little weight, using a 4-point response scale (0 = not at all, 1 = a little, 2 = a lot, and 3 = all the time).

Body mass index Z-score (BMIz) at age 13. Child BMIz was assessed via two indices at age 13 years. First, objective height and weight were obtained for those who completed a clinic visit at age 13 (median age at clinic visit = 13.8 years). Second, parents reported child height and weight via questionnaire (median age = 13.1). An age- and sex-adjusted BMIz was obtained from these self-report and clinic-recorded measurements. To maximize accuracy, when clinic-obtained measurements were obtained, this BMIz was used ($n = 5,226$). BMIz from parent report was used when clinic measurement was not available ($n = 710$).

Exercise measures. Questions related to maladaptive exercise were self-reported at ages 14, 16, 18, and 24 years. Questions were adapted from the Youth Risk Behavior Surveillance System (Kann et al., 1995).

Exercise for weight loss: The primary derived outcome variable of analysis for 'Exercise for Weight Loss' is an ordinal variable, defined as 0 = No, 1 = Sometimes, and 2 = Frequently. At ages 14, 16, and 18 years, participants were asked if they exercised to lose weight or avoid gaining weight, with response options of: No (0), Yes-Sometimes (1), and Yes-Frequently (2). At age 24, participants were asked the frequency with which they exercised to lose weight or avoid gaining weight, with response options of: Never, <1×/mo, 1–3×/mo, 1–4×/week, and 5 or more times per week. For the purposes of analysis, responses at age 24 were harmonized with age 14, 16, and 18. Responses of Never were binned as 'No' (0); 1×/mo - <1×/week were binned as 'Yes - Sometimes' (1), and 1x/wk or more as 'Yes - Frequently' (2). Once a week or more was chosen as the threshold for 'frequent' exercise for weight loss at age 24 to align with DSM-5 diagnostic frequency thresholds for other eating disorder behaviors, such as binge eating and purging (American Psychiatric Association, 2013).

Maladaptive exercise: At all assessment points, participants reported whether exercise interfered with work/school (14, 16, 18), or their daily routine (24). At ages 14 and 24, participants also reported whether they exercised to lose weight even when sick or injured. At ages 16 and 18, participants reported whether they felt guilty about missing an exercise session. Responses options were 'No', 'Yes - Sometimes', or 'Yes – Frequently'. Indicators of maladaptive exercise are deemed to be 'present' if an individual endorses: (1) exercise interfering with work/school sometimes or more AND/OR frequent guilt when missing an exercise session at ages 16 and 18 years and (2) exercise interfering with work/school/daily routine sometimes or more AND/OR exercising even when sick/injured sometimes or more at ages 14 and 24 years. The presence of 'maladaptive exercise' was defined as exercising for weight loss *sometimes or frequently* AND a *maladaptive exercise indicator* being present at each time point. Frequency of exercise for weight loss as sometimes or more was chosen as (1) existing literature suggests that frequency is less important than cognitive features in defining maladaptive exercise (Adkins & Keel, 2005; Mond, Hay, Rodgers, & Owen, 2006), and (2) the nature of the epidemiological sample and the concomitant goals of this paper were such that we were interested in identifying early risk indicators.

Exercise groups: Exercise groups over time are defined for descriptive analyses and transition states, replicating groups defined in Schaumberg et al. (2022). Those who report no exercise for weight loss at each time point (regardless of exercise frequency) are placed in a 'No Exercise for Weight Loss' group, those who report exercise for weight loss at least sometimes, but do not meet criteria for maladaptive exercise are placed in an 'Exercise for Weight Loss' group, and those meeting maladaptive exercise criteria are placed in the 'Maladaptive Exercise' group.

Analytic plan

Two primary analytic approaches were employed: transition analyses which clarified transitions between exercise groups over time (Aim 1), and mixed effects models which examined whether levels of exercise for weight loss and maladaptive exercise changed across age (Aim 2). A detailed analytic plan is outlined in Appendix S1. We elected to complete analysis stratified by sex at birth, as (1) it is consistent with prior work investigating eating disorder risk within the ALSPAC Cohort (Schaumberg et al., 2022), (2) evidence consistently indicates that the prevalence of both maladaptive exercise and eating disorder risk factors vary meaningfully across sex in the Cohort (Micali et al., 2015, 2017; Schaumberg et al., 2022), and (3) emerging literature suggests that both risk mechanisms and their developmental timing in relation to ED risk among males and females may differ substantially (Culbert, Sisk, & Klump, 2021). As such, we opted to employ a stratified approach to analysis in the current study to retain maximal sensitivity for within-sex effects.

Aim 1. Investigate rates of transition between 'No Exercise for Weight Loss', 'Exercise for Weight Loss', and 'Maladaptive Exercise' groups from ages 14–24, and characterize predictors of transitions to 'Maladaptive Exercise' among males and females.

The first step in analyses evaluated overall changes in the presence of exercise for weight loss and maladaptive exercise over time in the sample. Visualization was completed with transition plots (Cernat, 2021) for those completing all four assessment points. For those completing at least two assessment points, transition analysis included multi-state Markov models for panel data (Jackson, 2011), which describes how individuals move between exercise groups over time. An initial transition matrix was specified in which instantaneous transitions between adjacent states are permitted, as well as transitions between the Maladaptive Exercise-No Exercise for Weight Loss state (direct transition to exercise abstinence). Transition analyses were completed separately for males and females, and the fitted transition probability matrix $P(t)$ is reported over an interval of 1-year, which describes the likelihood of transition between exercise groups each year. Exploratory analyses of transition states examine whether baseline covariates (Parent SES, BMIz at age 13 years, eating disorder cognitions at age 14 years) impact transition intensities among the three exercise groups.

While Markov state models are useful in describing overall transition patterns, one notable limitation is the assumption under these models that transitions are time independent; that is, that transition to and from states is not dependent on age. This removes consideration of developmental timepoints that may be relevant as risk progresses. Further, the inclusion of covariates can test the effect of these covariates on specific transitions but does not test the effects of these covariates on overall risk of exercise for weight loss or driven exercise in the sample or influences of these covariates over time. As such, Aim 2 implements Mixed Effects Models to complement Aim 1 analyses.

Aim 2. Examine overall changes in probability exercise for weight loss and maladaptive exercise from ages 14–24 and characterize predictors of change in probability of maladaptive exercise and exercise for weight loss over time.

To complete Aim 2, Mixed Effects Models for ordinal and binary data (Christensen, 2015, 2019; Landerman, Mustillo, & Land, 2011) examined whether levels of exercise for weight loss and maladaptive exercise changed across age. Data were imputed prior to conducting mixed effects models, with 10 iterations on 20 imputed datasets. Imputation parameters and percent missing variables across gender are presented in Tables S5–S7. Parameter pooling was utilized to combine models fit to the imputed datasets. Nested models allow for a random intercept for each individual, followed by a fixed effect of Time (assessment point – with baseline set to 14 years), then fixed effects for all baseline predictors and covariates, and, finally, all Predictor × Time interactions. Models were compared via the multivariate Wald test, using the D1 statistic (van Buuren & Groothuis-Oudshoorn, 2011). See Appendix S1 for model parameters.

Results

Descriptive analyses

Covariates: SES, BMIz at age 13, ED cognitions at age 14. Descriptive information for continuous

variables is provided in Table S1. Descriptive statistics for ordinal variables (Parent SES and Fear of Weight Gain) are provided in Tables S2 and S3. Briefly, the distribution for BMIz at age 13 for both males and females is as expected, with means near 0 and standard deviations near 1 (Table S1). Median body dissatisfaction and thin-ideal internalization scores reflect generally neutral scores, with median body dissatisfaction scores lying between 'cannot decide' and 'moderately satisfied', and median thin-ideal internalization scores at a neutral point for both males and females (Table S1). Modal parent highest occupation class was 'Managerial and Technical' (Table S2), and the majority of both males (83.22%) and females (53.75%) who reported on fear of weight gain reported no fear of weight gain at age 14 years (Table S3).

Exercise variables. Exercise for weight loss frequency across age and gender is presented Figures S2 and S3. The percentage of participants reporting any exercise issues as present at each age is presented in Figures S4 and S5.

Exercise groups. Exercise status at ages 14–24 years in females and males, as a percentage of the total number of males and females who reported exercise data at the timepoint is presented in Figure 1. Raw percentage comparison indicates representation in exercise groups is relatively stable from ages 14–16 years, with the raw percentage of females reporting exercise for weight loss increasing from 30.1% to 40.7% from age 16 to 18 and the raw percentage of men reporting exercise for weight loss increasing from 15.7% to 27.7% in males from ages 18 to 24. The largest percentage of females (25.0%) and males (20.2%) reported maladaptive exercise at age 24, relative to other ages.

Transitions in exercise groups over time

A subset of females ($N = 1{,}169$) and males ($N = 568$) completed all assessments from ages 14–24. To aid with visualizing transition intensities across exercise groups and age, Figure 2A,B shows the frequency of completers who transitioned from each of the three exercise groups to other groups across age.

H1a

Maladaptive exercise will be moderately persistent; that is, individuals will be likely to remain in this category once they transition into the category.

To assess the hypothesis that 'Maladaptive Exercise' would be persistent, we examined Transition Probabilities from the 'Maladaptive Exercise' group to each of the three groups over the course of a year (see Table 1), expecting stability in the 'Maladaptive Exercise' group to be >50%. Among both males and females in the 'Maladaptive Exercise' group, remaining in the 'Maladaptive Exercise' group was indeed the most common 1-year outcome, with likelihood of remaining in the 'Maladaptive Exercise' Group estimated at 60.3% for females and 62.9% for males.

H1b

Transitions between the 'Exercise for Weight Loss' and 'Maladaptive Exercise' categories will be more common than transitions between the 'No Exercise for Weight Loss' and 'Maladaptive Exercise' categories.

Females. Raw numbers for each transition (Table S3), the transition probabilities across 1-year (Table 1), and a figure depicting the observed versus expected prevalence (Figure S6a), indicate that the highest probability outcome for each group over the course of a 1-year period was staying in that group, followed by transition to a neighboring group, with transitions between 'No Exercise for Weight Loss' and 'Maladaptive Exercise' groups being the least likely transitions, and likelihood of transition from 'No Exercise for Weight Loss' to 'Maladaptive Exercise' in 1 year being rare for those starting in the 'No Exercise for Weight Loss' category – about 2.4%.

When covariates were introduced, higher BMIz at age 13 was associated with increased likelihood of transition from 'No Exercise for Weight Loss' to 'Exercise for Weight Loss' over the course of a year, with a standard deviation increase in BMIz predicting a 43% increase in likelihood of transition in a given year (see Table S4 for full results).

Males. Raw transitions among males (Table S3), transition probabilities across 1-year (Table 2), and a figure depicting the observed vs. expected prevalence in each group (Figure S6b) indicate that stability in the 'No Exercise for Weight Loss' group was common, and stability in all groups was the most common 1-year outcome. There was a moderate probability ($\sim$16%–20%) of males in the 'Exercise for Weight Loss' group transitioning to either the 'No Exercise for Weight Loss' or 'Maladaptive Exercise' groups over a 1-year period. Similarly, males in the 'Maladaptive Exercise' group showed a moderate probability of transitioning to either the Exercise for Weight Loss (18%) or 'No Exercise for Weight Loss' (19%) group over a 1-year period. Models including covariates did not converge for males, due to low base rates of some transitions.

Mixed effects models – maladaptive exercise over time

H2a

The prevalence of exercise for weight loss and maladaptive exercise will show modest increases

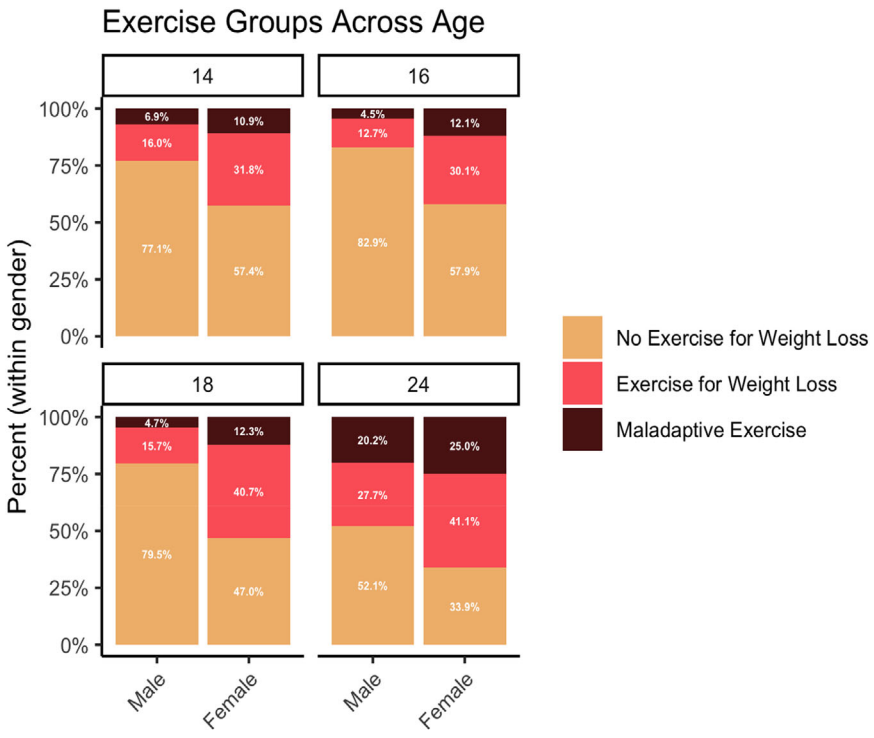

Figure 1 Frequency of exercise groups across age

with age, reflecting transition through peak age of onset for EDs during late adolescence.

H2b

ED cognitions at age 14 will predict maladaptive exercise and exercise for weight loss across adolescent and young adult development, with strongest prediction at most proximal timepoints.

Mixed effects logistic regression models examined changes in maladaptive exercise across age, along with baseline (age 14) predictors, and interactions between baseline predictors and the linear effect of age.

Females. Model comparisons (Table 2) indicated that the most complex (Step 3) model fit best. Results for females are reported in Table 3. In the baseline model, a substantial portion of females (~ 13%) reported maladaptive exercise. In the final model, Age, BMIz (Age 13), and Fear of Weight Gain (age 14), and Thin-ideal Internalization (Age 14) also reached significance. A one-unit in fear of weight gain (e.g., increasing from 'Not at All' afraid of weight gain, the median response, to 'A Little' afraid of weight gain) was associated with odds of maladaptive exercise increasing by 80%, while a one standard deviation increase in thin-ideal internalization mean was associated with a modest (14%) increase in odds of maladaptive exercise during adolescence.

Males. For males, the Step 2 model optimized fit (see Table 2). Full results are presented in Table 3. There was a significant effect of Age, such that maladaptive exercise endorsement was more common as males aged (odds increasing at ~ 10% per year). Age 13 BMIz was again a significant predictor, with odds of maladaptive exercise during adolescence increasing 74% with a 1SD increase in BMIz. Effects for Fear of Weight Gain and Thin-ideal Internalization also reached significance.

Mixed-Effect models – exercise for weight loss

Summary statistics for model comparisons are presented in Table 4.

Females. The most complex model (including Age × Predictor interactions) was identified as the best model fit for females. Age, Parent SES, BMIz at age 13, Thin-ideal Internalization, Body Dissatisfaction, and Fear of Weight Gain were all positive predictors of exercise for weight loss frequency (see Table 5 for coefficients), along with Body Dissatisfaction × Age and Fear of Weight Gain × Age interactions, indicating timepoints more proximal to measurement were better predicted, with some attenuation of the potency of these predictors across age.

Males. The model including all covariates and Age × Predictor interactions fit most optimally (see

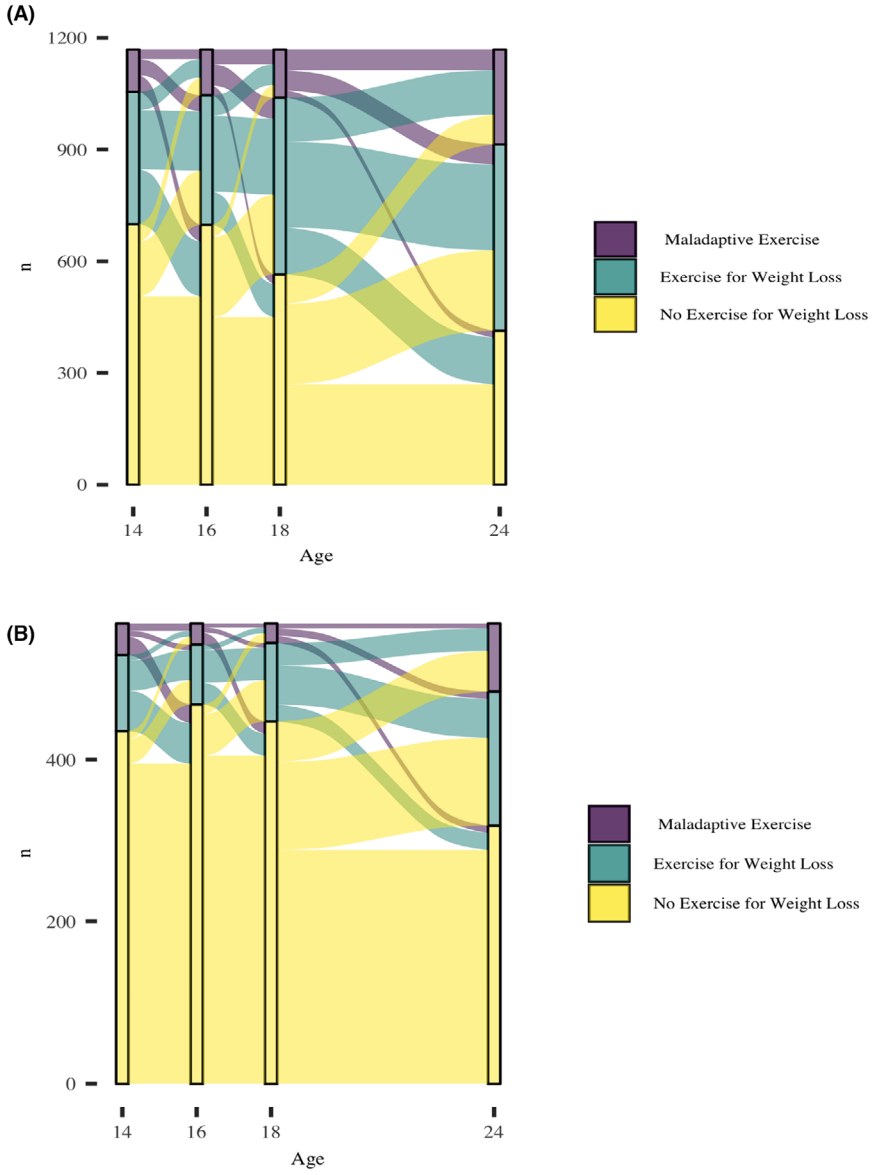

Figure 2 (A) Transitions across exercise groups in females. (B) Transitions across exercise groups in males

Table 1 Estimates of transition probabilities across 1-year: from (rows) – to (cols)

	No EWL	EWL	Maladaptive Ex
Girls			
No EWL	0.788 (0.774, 0.800)	0.188 (0.177, 0.200)	0.024 (0.021, 0.028)
EWL	0.157 (0.139, 0.176)	0.675 (0.652, 0.697)	0.168 (0.151, 0.186)
Maladaptive Ex	0.106 (0.085, 0.139)	0.291 (0.249, 0.340)	0.603 (0.553, 0.647)
Boys			
No EWL	0.897 (0.887, 0.906)	0.091 (0.083, 0.101)	0.012 (0.009, 0.014)
EWL	0.203 (0.172, 0.239)	0.629 (0.589, 0.667)	0.168 (0.140, 0.197)
Maladaptive Ex	0.193 (0.152, 0.251)	0.178 (0.120, 0.268)	0.629 (0.539, 0.697)

Transitions based on the *Q*-matrix allowing direct transitions across all groups, with the exception of instantaneous transition from 'No Exercise for Weight Loss' to 'Maladaptive Exercise'. EWL, 'Exercise for Weight Loss'; Maladaptive Ex, 'Maladaptive Exercise'.

Table 5). Age, BMIz at age 13, and Fear of Weight Gain were all robust predictors of exercise for weight loss during adolescence. Odds of exercise for weight loss increased modestly for each year of age, with pronounced increases in exercise for weight loss as BMIz (age 13) and Fear of Weight Gain (age 14) increased. As with females, there was a significant Age × Fear of Weight Gain interaction.

Table 2 Model comparisons – maladaptive exercise

	Statistic	*df*1	*df*2	*p* Value	riv
Females					
Baseline vs. Age effects	126.451	1	181.458	.000	0.364
Age vs. Step 1 Covs	40.781	2	164.598	.000	0.799
Step 1 Covs vs. Step 2 Covs	54.459	3	285.864	.000	0.727
Step 2 Covs vs. Step 3 Age × Cov interactions	4.715	4	1,068.449	.001	0.328
Males					
Baseline vs. Age effects	78.096	1	138.376	.000	0.445
Age vs. Step 1 Covs	61.979	2	103.188	.000	1.322
Step 1 Covs vs. Step 2 Covs	21.106	3	179.303	.000	1.158
Step 2 Covs vs. Step 3 Age × Cov interactions	2.053	4	466.362	.086	0.616

Discussion

Transitions across exercise groups

Altogether, transitions between exercise groups were common in both females and males. Stability in the 'No Exercise for Weight Loss' group was highest of all three groups, and, as hypothesized (supporting H1a), stability in the 'Exercise for Weight Loss' and 'Maladaptive Exercise' groups was also common (~ 60%–70% stability from year-to-year). Also as hypothesized (supporting H1b), transitions were more common to and from 'Exercise for Weight Loss' and 'Maladaptive Exercise' as compared to the 'No exercise for Weight Loss' and 'Maladaptive Exercise' group. Moderate rates of transition suggest that, among the population-based sample, intervening on psychological motivations for exercise is possible and could impact progression from adaptive to maladaptive exercise engagement.

Rates of exercise for weight loss and maladaptive exercise over time

Overall, individuals in the ALSPAC sample reported engaging in exercise for weight loss and maladaptive exercise at relatively high rates across adolescence, and endorsement of both behaviors increased over time (supporting H2a). The relatively high and increasing rates of exercise for weight loss and maladaptive exercise across adolescence are consistent with previous research (Allen et al., 2013) and are of potential concern as previous research in this cohort suggests that exercise for weight loss and maladaptive exercise at age 14 are associated with increased risk of other ED symptoms (Schaumberg et al., 2022).

One interpretation of increases in exercise for weight loss and across age is that variation in response options at age 24 may have influenced rates of endorsement; however, exercise for weight loss also increased steadily for females between ages 14–18 when questions were identical. A second interpretation of this increase is that, at younger ages, children are more commonly involved in more structured sport and exercise programs, and weight loss could transition to be a primary motivator for exercise as sports participation diminishes in later adolescence. Of note, rates of endorsement of weight loss as a motivator for exercise appear to eclipse rates of excess weight gain and obesity during this time period, as the rate of obesity (>95th percentile BMIz) at age 15 years in the ALSPAC cohort is 12.4%, with only 1.4% of the sample showing incident obesity between ages 11–15 years (Hughes, Sherriff, Lawlor, Ness, & Reilly, 2011), suggesting that the growing weight loss motivation for exercise is not exclusive to those for whom weight loss may have been medically prescribed. The high rates of a weight loss motivation for exercise in this sample suggest that exercise may be 'linked' with weight management, and increasingly so, across adolescent development. The pairing of exercise and weight management, while generally considered innocuous or even beneficial, may be concerning among adolescents on a population scale for the following reasons:

1. Weight loss is not indicated for the high percentage of the adolescent population endorsing this motivation.
2. A focus on the external motivation of weight loss to support exercise engagement may diminish the potency of other motivations and intrinsic reinforcers associated with exercise over time. As compared to external motivations, autonomous motivators are more likely to support long-term health behavior change (Deci & Ryan, 2008; Ng et al., 2012) including levels of healthy (vs. maladaptive) exercise (Staples, Palermo, & Rancourt, 2022).
3. Exercise for weight loss may lead to maladaptive exercise, a pattern observed over time in the current sample, and can exacerbate ED risk among high-risk youth.

Predictors of maladaptive exercise

ED cognitions. With regard to predictors of maladaptive exercise, ED cognitions at age 14 predicted increased odds for both exercise for weight loss and maladaptive exercise across development (supporting H2b – Thin-ideal Internalization and Fear of Weight Gain as predictors of maladaptive exercise over time). The most consistent and strongest

Table 3 Parameter estimates for models predicting maladaptive exercise

Model	Term	Estimate	*SE*	0.25%	99.75%
Females					
Baseline Model	**(Intercept)**	**0.133**	0.042	0.017	0.250
Age Effect Model	(Intercept)	0.094	0.052	−0.051	0.240
Age Effect Model	**Age**	**1.079**	0.007	1.060	1.098
Step 1 Covariates	(Intercept)	0.082	0.132	−0.289	0.453
Step 1 Covariates	**Age**	**1.080**	0.007	1.060	1.099
Step 1 Covariates	Parent SES	1.015	0.034	0.919	1.112
Step 1 Covariates	**BMIz - Age 13**	**1.348**	0.033	1.257	1.439
Step 2 Covariates	(Intercept)	0.063	0.134	−0.314	0.441
Step 2 Covariates	**Age**	**1.080**	0.007	1.061	1.099
Step 2 Covariates	Parent SES	1.015	0.034	0.920	1.110
Step 2 Covariates	**BMIz - Age 13**	**1.181**	0.034	1.086	1.276
Step 2 Covariates	**Fear of Wt Gain – Age 14**	**1.624**	0.042	1.507	1.742
Step 2 Covariates	Body Dissatisfaction – Age 14	1.062	0.034	0.966	1.159
Step 2 Covariates	Thin-ideal Internalization – Age 14	1.092	0.035	0.993	1.191
Step 3 Age × Cov	(Intercept)	0.057	0.138	−0.332	0.446
Step 3 Age × Cov	**Age**	**1.103**	0.009	1.077	1.129
Step 3 Age × Cov	Parent SES	1.015	0.034	0.920	1.111
Step 3 Age × Cov	**BMIz – Age 13**	**1.181**	0.045	1.054	1.309
Step 3 Age × Cov	**Fear of Wt Gain – Age 14**	**1.801**	0.055	1.645	1.956
Step 3 Age × Cov	Body Dissatisfaction – Age 14	1.124	0.048	0.989	1.260
Step 3 Age × Cov	**Thin-ideal Internalization – Age 14**	**1.147**	0.049	1.009	1.285
Step 3 Age × Cov	Age × BMIz (13)	1.000	0.007	0.981	1.019
Step 3 Age × Cov	Age × Fear of Wt Gain (14)	0.977	0.008	0.954	1.000
Step 3 Age × Cov	Age × Body Satisfaction (14)	0.988	0.007	0.968	1.008
Step 3 Age × Cov	Age × Thin-Ideal Internalization (14)	0.990	0.007	0.971	1.008
Males					
Baseline Model	(Intercept)	0.050	0.085	−0.189	0.289
Age Effect Model	(Intercept)	0.032	0.108	−0.271	0.335
Age Effect Model	**Age**	**1.096**	0.010	1.067	1.126
Step 1 Covariates	(Intercept)	0.030	0.240	−0.646	0.706
Step 1 Covariates	**Age**	**1.097**	0.011	1.068	1.127
Step 1 Covariates	Parent SES	0.984	0.061	0.812	1.155
Step 1 Covariates	**BMIz – Age 13**	**1.867**	0.054	1.717	2.018
Step 2 Covariates	(Intercept)	0.027	0.238	−0.641	0.694
Step 2 Covariates	**Age**	**1.098**	0.010	1.069	1.127
Step 2 Covariates	Parent SES	0.997	0.061	0.827	1.167
Step 2 Covariates	**BMIz – Age 13**	**1.739**	0.056	1.581	1.896
Step 2 Covariates	**Fear of Wt Gain – Age 14**	**1.886**	0.086	1.643	2.129
Step 2 Covariates	Body Dissatisfaction – Age 14	1.008	0.056	0.850	1.166
Step 2 Covariates	**Thin-ideal Internalization – Age 14**	**1.192**	0.064	1.013	1.371

Significant coefficients in bold.

cognitive predictor was fear of weight gain. Recent studies have highlighted the potential etiological centrality of fear of weight gain in ED development (Levinson & Williams, 2020), and results from the current paper underscore this cognitive feature as particularly salient in the prediction of maladaptive exercise. The strong associations between fear of weight gain and both exercise for weight loss and maladaptive exercise suggest that youth who are afraid of gaining weight may experiment with exercise as a means of mitigating this fear, which, in some cases, could entrench exercise in a maladaptive, fear-based behavioral pattern. Interventions which address ED cognitions to prevent ED behaviors should consider fear of weight gain as a potential target to preempt risk for maladaptive exercise. While associations between thin-ideal internalization and maladaptive exercise were less robust, these also reached significance and further investigation into these associations is warranted, particularly in light of modest internal consistency of the IBSS-R in this study.

In addition to fear of weight gain, thin-ideal internalization at age 14 years was associated with increases in odds of maladaptive exercise across gender, along with exercise for weight loss among females, with modest effects. Body dissatisfaction, on the other hand, was not a consistent predictor of maladaptive exercise patterns (limited support for H2b regarding body dissatisfaction).

With regard to Age × Predictor interactions, cognitive predictors tended to be strongest at timepoints more proximal to measurement (age 14) in predicting exercise for weight loss; however, no Age × Predictor interactions were significant in the maladaptive exercise model, suggesting that cognitive ED symptoms at age 14 are robust in their associations with maladaptive exercise even at later ages (partial

Table 4 Model comparison table for exercise for weight loss

Model	AIC	Model comparison	Median −2LL difference	*df*	*p*-Value
Females					
Age Model	34,809.62		NA		NA
Step 1 Covs	34,227.38	Age vs. Step 1 Covs	573.20	2	0
Step 2 Covs	33,773.57	Step 1 Covs vs. Step 2 Covs	463.60	3	0
Step 3 Covs	33,696.10	Step 2 Covs vs. Step 3 Age × Cov	85.12	4	0
Males					
Age Model	19,021.00		NA		NA
Step 1 Covs	18,300.84	Age vs. Step 1 Covs	720.50	2	0e+00
Step 2 Covs	18,162.73	Step 1 Covs vs. Step 2 Covs	145.80	3	0e+00
Step 3 Covs	18,133.78	Step 2 Covs vs. Step 3 Age × Cov interactions	38.01	4	1e-07

Table 5 Parameter estimates for models predicting exercise for weight loss

Model	Term	OR	OR LCI	OR HCI
Females				
Age Effect Model	**0|1**	**1.461**	1.330	1.605
Age Effect Model	**1|2**	**7.433**	6.536	8.453
Age Effect Model	**Age**	**1.113**	1.097	1.129
Step 1 Covariates	**0|1**	**2.107**	1.579	2.813
Step 1 Covariates	**1|2**	**10.712**	7.954	14.427
Step 1 Covariates	**Age**	**1.113**	1.097	1.129
Step 1 Covariates	Parent SES	1.073	0.994	1.159
Step 1 Covariates	**BMIz – Age 13**	**1.565**	1.463	1.673
Step 2 Covariates	**0|1**	**2.727**	2.063	3.607
Step 2 Covariates	**1|2**	**13.884**	10.392	18.550
Step 2 Covariates	**Age**	**1.113**	1.097	1.129
Step 2 Covariates	Parent SES	1.069	0.995	1.149
Step 2 Covariates	**BMIz – Age 13**	**1.377**	1.280	1.481
Step 2 Covariates	**Fear of Wt Gain – Age 14**	**1.640**	1.485	1.811
Step 2 Covariates	Body Dissatisfaction – Age 14	1.066	0.995	1.143
Step 2 Covariates	**Thin-ideal Internalization – Age 14**	**1.094**	1.022	1.172
Step 3 Age × Cov	**0|1**	**3.029**	2.241	4.094
Step 3 Age × Cov	**1|2**	**15.537**	11.351	21.267
Step 3 Age × Cov	**Age**	**1.139**	1.115	1.163
Step 3 Age × Cov	Parent SES	1.070	0.995	1.151
Step 3 Age × Cov	**BMIz – Age 13**	**1.456**	1.334	1.589
Step 3 Age × Cov	**Fear of Wt Gain – Age 14**	**1.820**	1.615	2.052
Step 3 Age × Cov	**Body Dissatisfaction – Age 14**	**1.143**	1.043	1.251
Step 3 Age × Cov	**Thin-ideal Internalization – Age 14**	**1.109**	1.013	1.215
Step 3 Age × Cov	Age × BMIz (13)	0.987	0.974	1.000
Step 3 Age × Cov	**Age × Fear of Wt Gain (14)**	**0.974**	**0.954**	0.995
Step 3 Age × Cov	**Age × Body Satisfaction (14)**	**0.984**	**0.970**	0.997
Step 3 Age × Cov	Age × Thin-Ideal Internalization (14)	0.997	0.984	1.010
Males				
Age Effect Model	**0|1**	**5.663**	4.892	6.555
Age Effect Model	**1|2**	**19.940**	16.577	23.985
Age Effect Model	**Age**	**1.105**	1.084	1.126
Step 1 Covariates	**0|1**	**7.449**	5.055	10.975
Step 1 Covariates	**1|2**	**26.312**	17.424	39.734
Step 1 Covariates	**Age**	**1.105**	1.084	1.127
Step 1 Covariates	Parent SES	1.035	0.933	1.148
Step 1 Covariates	**BMIz – Age 13**	**1.896**	1.730	2.077
Step 2 Covariates	**0|1**	**8.399**	5.772	12.223
Step 2 Covariates	**1|2**	**29.741**	19.907	44.431
Step 2 Covariates	**Age**	**1.105**	1.084	1.127
Step 2 Covariates	Parent SES	1.044	0.944	1.155
Step 2 Covariates	**BMIz – Age 13**	**1.791**	1.625	1.974
Step 2 Covariates	**Fear of Wt Gain – Age 14**	**1.730**	1.431	2.090
Step 2 Covariates	Body Dissatisfaction – Age 14	1.009	0.911	1.119
Step 2 Covariates	Thin-ideal Internalization – Age 14	1.057	0.958	1.167
Step 3 Age × Cov Interactions	**0|1**	**9.226**	6.233	13.657

Significant effects in bold. OR, odds ratio; LCI, 0.25% lower confidence interval; HCI, 99.75% upper confidence interval.

support for H2b – Age × Predictor interactions only for exercise for weight loss).

Age 13 BMIz. While there were no a priori hypotheses regarding BMIz as a predictor of maladaptive exercise, BMIz at age 13 was consistently, positively associated with both exercise for weight loss and maladaptive exercise. Further, BMIz at age 13 related to increased odds of transitioning from the 'No Exercise for Weight Loss' group to the 'Exercise for Weight Loss' group over time among females. On the one hand, it is possible that youth at higher weights are both receiving and internalizing messages from media, peers, family, and health professionals to utilize exercise for weight loss at higher rates than lower-weight, same-sex peers. However, the association between BMIz at age 13 with *not only* exercise for weight loss *but also* maladaptive exercise suggests that these messages are not leading to exercise behavior that is exclusively innocuous or health promoting, and that youth with higher BMIs may be particularly susceptible to the development of a psychologically problematic relationship with exercise.

Limitations

Data harmonization across age. As mentioned previously, one analytic limitation was slightly varying response options across ages. Data harmonization in the current study was informed by the existing literature on maladaptive exercise; however, complete harmonization across ages was not possible, and may influence endorsement of exercise for weight loss and maladaptive exercise symptoms across age.

Assessment gap between 18 and 24 years. Second, while individuals provided data every 2 years from ages 14–18, there was a longer gap between measurements from ages 18 to 24 years. Time between assessments was modeled reflecting real time in both analytic approaches; however, this larger gap leaves some question as to the nature of change in exercise patterns during transition to young adulthood.

Model convergence for transition models. Third, while maladaptive exercise was common in both males and females as individuals transitioned to young adulthood, it was less common (<7% endorsement) among males at younger ages. As a result, there was limited ability to examine predictors of transitions between exercise groups among males.

Snapshot of Anglo-Western Culture. Fourth, while relatively rich information about exercise cognitions across development in this cohort provides a snapshot of the prevalence of maladaptive exercise behaviors, this snapshot is necessarily contextualized in time and place, specifically, a predominately White sample of youth in the early 21st century. It is likely that rates of exercise for weight loss and maladaptive exercise vary in other adolescent populations. Another limitation of the cohort includes that sex assigned at birth was the only information relevant to sex and gender available in analyses, as information about gender identity throughout adolescence was not assessed during development.

Future directions

The current paper lays groundwork to untangle distinctions between adaptive and maladaptive exercise behavior across adolescence and young adulthood. While initial work suggests that maladaptive exercise predicts exacerbation of other ED behaviors (Brosof et al., 2020; Schaumberg et al., 2022), future work should clarify associations between exercise for weight loss and ED risk, particularly in late adolescence.

Further, the degree to which psychological motivations for exercise and maladaptive exercise symptoms associate with objective exercise behavior (frequency, intensity of exercise) and interactions between activity patterns and weight loss motivations in the development and maintenance of maladaptive exercise patterns is currently unclear. In addition, while we included several potential predictors of maladaptive exercise in adolescence, additional investigations may consider a broader range of potential predictors (e.g., genetic, neurobiological, psychiatric traits beyond ED risk), including those measured earlier in development. Finally, examination of prospective associations between exercise for weight loss, BMIz, and ED symptoms would clarify the degree to which exercise for weight loss impacts BMIz trajectories in either adaptive or maladaptive ways, including whether exercise for weight loss is likely to pre-date growth curve deviations that signal disordered eating.

Conclusions

Building from initial work investigating exercise for weight loss and maladaptive exercise in early adolescence, this study examines rates of exercise for weight loss and maladaptive exercise longitudinally across 10 years of adolescent and young adult development. Findings highlight high and increasing rates of both exercise for weight loss and maladaptive exercise across adolescence and bring to question the degree to which marketing and public health messages associating exercise with weight loss may impact young people's experiences of exercise. Further, youth reporting ED cognitions in early adolescence may be most likely to internalize weight loss motivations for exercise and develop a problematic relationship

with exercise. Given current findings, we believe that efforts to unpair exercise from weight loss motivations among teens and young adults, particularly those otherwise at risk for disordered eating, are indicated. Further, interventions that promote greater attunement to exercise reinforces aside from weight management (e.g., social connection, mastery of new skills, emotion regulation) could aid in supplanting weight loss motivations to develop more sustainable, adaptive, and flexible exercise habits among youth.

Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article:

Table S1. Continuous variable descriptive statistics.
Table S2. Response frequencies for ordinal variables.
Table S3. Raw number of exercise state transitions.
Table S4. Hazard ratios for transitions with baseline covariates with transitions between maladaptive Ex and No EWL constrained – females.
Table S5. Imputation data.
Table S6. Predictor matrix for multiple imputation.
Table S7. Missing data prior to imputation.
Figure S1. Sample size across ages.
Figure S2. Exercise for weight loss across age.
Figure S3. Age 24 raw exercise for weight loss percentages.
Figure S4. Endorsement of exercise interfering with work, school or daily activities across age.
Figure S5. Endorsement of exercise issues across age.
Figure S6. Observed versus expected exercise group membership based on transition analysis.

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The authors made the following contributions. K.S.: Conceptualization, Data Preparation, Data Analysis, Writing - Original Draft Preparation, Editing - Review; C.M.B.: Conceptualization, Editing - Review; N.M.: Conceptualization, Editing - Review.

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Key points

- Exercise for weight loss and maladaptive exercise (exercise that results in negative consequences or interference with daily life) are common behaviors among youth and associated with increased risk of disordered eating symptoms.
- We clarify frequency with which young people transition between engaging in exercise for weight loss and experience negative consequences of this behavior in an epidemiological sample.
- Endorsement of exercise for weight loss and maladaptive exercise increased over ages 14–24 in both males and females.
- Body mass index (BMI; Age 13) and fear of weight gain (Age 14) were consistent predictors of maladaptive exercise across sex.
- Results support re-framing motivations for exercise in youth away from weight loss at a population level and targeting reductions in fear of weight gain for high-risk individuals.

References

Adan, R.A.H., Hillebrand, J.J.G., Danner, U.N., Cano, S.C., Kas, M.J.H., & Verhagen, L.A.W. (2010). Neurobiology driving hyperactivity in activity-based anorexia. In R. Adan, & W. Kaye (Eds.), *Behavioral neurobiology of eating disorders*. Current Topics in Behavioral Neurosciences (Vol. 6, pp. 229–250). Berlin, Heidelberg: Springer. https://doi.org/10.1007/7854_2010_77

Adkins, E.C., & Keel, P.K. (2005). Does "excessive" or "compulsive" best describe exercise as a symptom of bulimia nervosa. *The International Journal of Eating Disorders*, *38*, 24–29.

Allen, K.L., Crosby, R.D., Oddy, W.H., & Byrne, S.M. (2013). Eating disorder symptom trajectories in adolescence: Effects of time, participant sex, and early adolescent depressive symptoms. *Journal of Eating Disorders*, *1*, 32.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders*. Arlington, VA: American Psychiatric Publishing.

Biddle, S.J.H., Ciaccioni, S., Thomas, G., & Vergeer, I. (2019). Physical activity and mental health in children and adolescents: An updated review of reviews and an analysis of causality. *Psychology of Sport and Exercise*, *42*, 146–155.

Bornioli, A., Lewis-Smith, H., Slater, A., & Bray, I. (2021). Body dissatisfaction predicts the onset of depression among adolescent females and males: A prospective study. *Journal of Epidemiology and Community Health*, *75*, 343–348.

Bornioli, A., Lewis-Smith, H., Smith, A., Slater, A., & Bray, I. (2019). Adolescent body dissatisfaction and disordered eating: Predictors of later risky health behaviours. *Social Science & Medicine*, *238*, 112458.

Boyd, A., Golding, J., Macleod, J., Lawlor, D.A., Fraser, A., Henderson, J., … & Davey Smith, G. (2013). Cohort profile: The 'children of the 90s'—The index offspring of the Avon longitudinal study of parents and children. *International Journal of Epidemiology*, *42*, 111–127.

Brosof, L.C., Williams, B.M., & Levinson, C.A. (2020). Exploring the contribution of exercise dependence to eating disorder symptoms. *International Journal of Eating Disorders*, *53*, 123–127.

Calzo, J.P., Austin, S.B., & Micali, N. (2018). Sexual orientation disparities in eating disorder symptoms among adolescent boys and girls in the UK. *European Child and Adolescent Psychiatry*, *27*, 1483–1490.

Cernat, A. (2021). Visualizing transitions in time using R. Alexandru Cernat. Available from: https://www.alexcernat.com/visualizing-transitions-in-time-using-r/ [last accessed 26 May 2023]

Chekroud, S.R., Gueorguieva, R., Zheutlin, A.B., Paulus, M., Krumholz, H.M., Krystal, J.H., & Chekroud, A.M. (2018). Association between physical exercise and mental health in 1.2 million individuals in the USA between 2011 and 2015: A cross-sectional study. *Lancet Psychiatry*, *5*, 739–746.

Christensen, R.H.B. (2015). *Analysis of ordinal data with cumulative link models—Estimation with the R-package ordinal*. R-Package Version, 28, 31.

Christensen, R.H.B. (2019). *A tutorial on fitting cumulative link mixed models with clmm2 from the ordinal package*. Available from: https://Cran.r-Project.Org/Web/Packages/Ordinal/ [last accessed 10 January 2023]

Culbert, K.M., Sisk, C.L., & Klump, K.L. (2021). A narrative review of sex differences in eating disorders: Is there a biological basis? *Clinical Therapeutics*, *43*, 95–111.

Dalle Grave, R., Calugi, S., & Marchesini, G. (2008). Compulsive exercise to control shape or weight in eating disorders: Prevalence, associated features, and treatment outcome. *Comprehensive Psychiatry*, *49*, 346–352.

Davis, C., Kennedy, S.H., Ravelski, E., & Dionne, M. (1994). The role of physical activity in the development and maintenance of eating disorders. *Psychological Medicine*, *24*, 957–967.

Davis, H.A., Guller, L., & Smith, G.T. (2016). Developmental trajectories of compensatory exercise and fasting behavior across the middle school years. *Appetite*, *107*, 330–338.

Deci, E.L., & Ryan, R.M. (2008). Self-determination theory: A macrotheory of human motivation, development, and health. *Canadian Psychology/Psychologie Canadienne*, *49*, 182–185.

Deslandes, A., Moraes, H., Ferreira, C., Veiga, H., Silveira, H., Mouta, R., … & Laks, J. (2009). Exercise and mental health: Many reasons to move. *Neuropsychobiology*, *59*, 191–198.

Dittmer, N., Jacobi, C., & Voderholzer, U. (2018). Compulsive exercise in eating disorders: Proposal for a definition and a clinical assessment. *Journal of Eating Disorders*, *6*, 42.

Fietz, M., Touyz, S., & Hay, P. (2014). A risk profile of compulsive exercise in adolescents with an eating disorder: A systematic review. *Advances in Eating Disorders*, *2*, 241–263.

Fraser, A., Macdonald-Wallis, C., Tilling, K., Boyd, A., Golding, J., Davey Smith, G., … & Lawlor, D.A. (2013). Cohort profile: The Avon longitudinal study of parents and children: ALSPAC mothers cohort. *International Journal of Epidemiology*, *42*, 97–110.

García-Hermoso, A., Ramírez-Vélez, R., & Saavedra, J.M. (2019). Exercise, health outcomes, and pædiatric obesity: A systematic review of meta-analyses. *Journal of Science and Medicine in Sport*, *22*, 76–84.

Gorrell, S., Flatt, R.E., Bulik, C.M., & Le Grange, D. (2021). Psychosocial etiology of maladaptive exercise and its role in eating disorders: A systematic review. *International Journal of Eating Disorders*, *54*, 1358–1376.

Harris, P.A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J.G. (2009). Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics*, *42*, 377–381.

Hughes, A.R., Sherriff, A., Lawlor, D.A., Ness, A.R., & Reilly, J.J. (2011). Incidence of obesity during childhood and adolescence in a large contemporary cohort. *Preventive Medicine*, *52*, 300–304.

Jackson, C. (2011). Multi-state models for panel Data: The msm package for R. *Journal of Statistical Software*, *38*, 1–28. https://doi.org/10.18637/jss.v038.i08

Kann, L., Warren, C.W., Harris, W.A., Collins, J.L., Douglas, K.A., Collins, M.E., … & Kolbe, L.J. (1995). Youth risk behavior surveillance—United States, 1993. *The Journal of School Health*, *65*, 163–171.

Landerman, L.R., Mustillo, S.A., & Land, K.C. (2011). Modeling repeated measures of dichotomous data. *Social Science Research*, *40*, 1456–1464.

Levinson, C.A., & Williams, B.M. (2020). Eating disorder fear networks: Identification of central eating disorder fears. *International Journal of Eating Disorders*, *53*, 1960–1973.

Micali, N., De Stavola, B., Ploubidis, G., Simonoff, E., Treasure, J., & Field, A.E. (2015). Adolescent eating disorder behaviours and cognitions: Gender-specific effects of child, maternal and family risk factors. *The British Journal of Psychiatry: The Journal of Mental Science*, *207*, 320–327.

Micali, N., Horton, N.J., Crosby, R.D., Swanson, S.A., Sonneville, K.R., Solmi, F., … & Field, A.E. (2017). Eating disorder behaviours amongst adolescents: Investigating classification, persistence and prospective associations with adverse outcomes using latent class models. *European Child & Adolescent Psychiatry*, *26*, 231–240.

Mond, J.M., Hay, P.J., Rodgers, B., & Owen, C. (2006). An update on the definition of "excessive exercise" in eating disorders research. *The International Journal of Eating Disorders*, *39*, 147–153.

Monell, E., Levallius, J., Forsén Mantilla, E., & Birgegård, A. (2018). Running on empty – A nationwide large-scale examination of compulsive exercise in eating disorders. *Journal of Eating Disorders*, *6*, 11.

Ng, J.Y.Y., Ntoumanis, N., Thøgersen-Ntoumani, C., Deci, E.L., Ryan, R.M., Duda, J.L., & Williams, G.C. (2012). Self-determination theory applied to health contexts: A meta-analysis. *Perspectives on Psychological Science*, *7*, 325–340.

Northstone, K., Lewcock, M., Groom, A., Boyd, A., Macleod, J., Timpson, N., & Wells, N. (2019). The Avon Longitudinal Study of Parents and Children (ALSPAC): An update on the enrolled sample of index children in 2019. *Wellcome Open Research*, *4*, 51.

Penedo, F.J., & Dahn, J.R. (2005). Exercise and well-being: A review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry*, *18*, 189–193.

Reynolds, K.A., Plateau, C.R., & Haycraft, E. (2022). Sociocultural influences on compulsive exercise in young people: A systematic review. *Adolescent Research Review*, *8*, 179–194.

Scharmer, C., Gorrell, S., Schaumberg, K., & Anderson, D. (2020). Compulsive exercise or exercise dependence? Clarifying conceptualizations of exercise in the context of eating disorder pathology. *Journal of Clinical Sport Psychology*, *46*, 101586.

Schaumberg, K., Robinson, L., Hochman, A., & Micali, N. (2022). Prospective associations between driven exercise and other eating disorder behaviors in adolescence: A longitudinal cohort study. *The Journal of Adolescent Health: Official Publication of the Society for Adolescent Medicine*, *70*, 781–787.

Schaumberg, K., Zerwas, S., Goodman, E., Yilmaz, Z., Bulik, C.M., & Micali, N. (2019). Anxiety disorder symptoms at age 10 predict eating disorder symptoms and diagnoses in adolescence. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *60*, 686–696. https://doi.org/10.1111/jcpp.12984

Solenberger, S.E. (2001). Exercise and eating disorders: A 3-year inpatient hospital record analysis. *Eating Behaviors*, *2*, 151–168.

Staples, C., Palermo, M., & Rancourt, D. (2022). Intrinsic and extrinsic motivations as moderators of the association between exercise frequency and exercise behavior. *Eating and Weight Disorders - Studies on Anorexia, Bulimia and Obesity.*, *27*, 2801–2809.

Stice, E. (2001). A prospective test of the dual-pathway model of bulimic pathology: Mediating effects of dieting and negative affect. *Journal of Abnormal Psychology*, *110*, 124–135.

Stice, E., Shaw, H., & Nemeroff, C. (1998). Dual pathway model of bulimia nervosa: Longitudinal support for dietary restraint and affect-regulation mechanisms. *Journal of Social & Clinical Psychology*, *17*, 129–149.

Stiles-Shields, E.C., Goldschmidt, A.B., Boepple, L., Glunz, C., & Le Grange, D. (2011). Driven exercise among treatment-seeking youth with eating disorders. *Eating Behaviors*, *12*, 328–331.

van Buuren, S., & Groothuis-Oudshoorn, K. (2011). Mice: Multivariate imputation by chained equations in R. *Journal of Statistical Software*, *45*(3), 1–67. https://doi.org/10.18637/jss.v045.i03

Yilmaz, Z., Schaumberg, K., Halvorsen, M., Goodman, E.L., Brosof, L.C., Crowley, J.J., … & Zerwas, S.C. (2022). Predicting eating disorder and anxiety symptoms using disorder-specific and transdiagnostic polygenic scores for anorexia nervosa and obsessive-compulsive disorder. *Psychological Medicine*, 1–15. https://doi.org/10.1017/S0033291721005079. Online ahead of print.

Zmijewski, C.F., & Howard, M.O. (2003). Exercise dependence and attitudes toward eating among young adults. *Eating Behaviors*, *4*, 181–195.

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